The Impact of a Workplace Environmental Change on Work- Related Outcomes:

Productivity, Presenteeism and Cognition

by

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A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved April 2014 by the
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ARIZONA STATE UNIVERSITY

May 2014

ABSTRACT

The purpose of this study was to examine whether a workplace environmental intervention would improve work-related outcomes including productivity, presenteeism and cognition. The secondary aim was to investigate whether work-related outcomes are correlated to observed changes in sitting time, physical activity, and sleep. The study was introduced as part of a naturalistic environmental change in which university staff and faculty were relocated into a new building (n=23). The comparison group consisted of university staff within the same college with no imminent plans to re-locate during the intervention period; there were no environmental changes to this workplace (n =10). Participants wore two behavioral monitoring devices, activPAL and GeneActiv, for 7 consecutive days at two time points (immediately prior and 16 weeks following the office relocation). Measures of productivity and presenteeism were obtained via four validated questionnaires and participants underwent cognitive performance testing. Baseline adjusted analysis of covariance statistical analyses were used to examine differences between groups in work-related outcomes. A residual analysis in regression was conducted to determine the differences between observed changes in sitting time, physical activity and sleep, and work-related outcomes. The results showed that a reduction in work hour sitting time was not detrimental to work related outcomes. Decreased sitting was observed to potentially improve presenteeism and absenteeism. Additionally, physical activity was shown to modestly improve productivity, presenteeism and absenteeism. Poor sleep patterns were associated with work impairment and increased absenteeism.

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LIST OF ABBREVIATIONS

ASBQ	Australian Sedentary Behavior Questionnaire
BAR	Bouchard Activity Record
BMI	Body Mass Index
BP	Blood Pressure
CVD	Cardiovascular Disease
ESM	Experience Sampling Methodology
ESS	Epworth Sleepiness Scale
EWPS	Endicott Work Productivity Scale
GENEA	Gravity Estimator of Normal Everyday Activity
GRE	Graduate Record Examinations
HDL	High-density Lipoprotein
HERO	Health Enhancement Research Study
HLQ	Health and Labor Questionnaire
HPQ	World Health Organization Health and Work Performance Questionnaire
HRA	Health Risk Assessment
IPAQ	International Physical Activity Questionnaire
LDL	Low-density Lipoprotein
LPL	Lipoprotein Lipase
MET	Metabolic equivalent
MS	Metabolic Syndrome
MVPA	Moderate to Vigorous Physical Activity
NEAT	Non-Exercise Activity Thermogenesis

OSPAQ	Occupational Sitting and Physical Activity Questionnaire
PSQI	Pittsburgh Sleep Quality Index
SPS-6	Stanford Presenteeism Scale
TMWS	Treadmill Workstations
TSH	Thyroid Stimulating Hormone
WAI	Work Ability Index
WHO	World Health Organization
WPAI:GH	Work Productivity and Activity Impairment General Health
WPSI	Work Productivity Short Inventory
WSA	Workforce Sitting Questionnaire
WLQ	Work Limitations Questionnaire

CHAPTER 1

INTRODUCTION

Health promotion in the workplace is becoming a growing among organizations. Employee wellness and the implementation of health promotion programs in the workplace serve to improve employee health, increase morale and attenuate healthcare costs. Studies have shown that healthy employees have increased work productivity, as a result of the combined effect on medical costs, absences, work performance and turnover (15). Various health risks can impact work related costs and productivity outcomes. Health risks in the workplace can include risk categories such as: alcohol, nutrition, emotional health, physical inactivity, safety, blood pressure, blood glucose, cholesterol, triglycerides, weight, and tobacco. Research has consistently demonstrated a linear relationship between the number of health risks and productivity loss and suggested that employees who have more health risks experienced absenteeism and presenteeism than employees with fewer risks (15). The Commonwealth Fund estimates that health-related productivity loss costs $260 billion in the United States (86). Productivity in the workplace is linked to absenteeism and presenteeism, both of which are affected by health risks (132, 15) Absenteeism is an employee’s time away from office related to medical absences, disability, or worker’s compensation. The relationship between absenteeism and workplace productivity is an objective measurement, because costs associated with absenteeism has a causal effect on lost productivity. Presenteeism, on the other hand, is not quite the opposite of absenteeism. Presenteeism is defined as “the percentage of time impaired while on the job, e.g., decreased productivity and below-normal work quality” (99). It is the reduced ability to work productively due to a physical or health impairment. Presenteeism is measured as the costs associated with "reduced work output, error of the job, and failure to meet company production standards" (111). Unlike absenteeism, it is difficult to objectively assess the impact of presenteeism especially in an office-based environment (22). However, studies suggest that presenteeism accounts for a larger proportion of losses than absenteeism (86), approximately 5.1 times more costly than costs incurred for absenteeism (20). As a result, presenteeism is becomingly a widely researched productivity measure and an important outcome in physical activity and sedentary behavior research in the workplace (20).

Past studies have suggested that emotional health risk factors such as depression and stress had the highest impact on work productivity and medical expenditures (45). Depression in particular was found to be detrimental to work performance and has negative effects of cognitive functioning (16). Effective cognitive functioning is needed to be successful in the workplace and cognition training can be considered a preventative health benefit to working adults (16). More so, evidence suggests that physical activity is an integral element in promoting healthy and effective cognitive functioning (68, 71, 58). As the health risk profile of American workers is changing over time, current research is now demonstrating a shift of prevalent health risks with productivity loss. A recent Health Enhancement Research Organization (HERO) study suggested that physical inactivity was a considerable predictor of health risks accounting for 10.4 to 15.3% of increased medical costs (46). A systematic review which evaluated health promotions programs and presenteeism in the workplace, found that exercise is beneficial in improving presenteeism. Investigators surmised that "physical inactivity is shown to be nearly 62% more costly than depression" (78). At the same rate, physical inactivity and sedentary behavior is becoming a national epidemic as thirty-two percent of Americans do not engage in leisure-time physical activity (38). Sedentary behavior, or too much sitting, refers to “waking activity characterized by an energy expenditure of ≤ 1.5 METS and a sitting or reclining position” (113) and includes activities such as sitting, lying down, and watching television (98). Environmental and societal changes within the past 50 years have attributed to an inactive lifestyle, which is now a problematic concern due to the deleterious health consequences. The health risks associated with sedentary behavior are now becoming evident. Sedentary behavior is a distinct risk factor for multiple health outcomes, such as chronic health condition such as CVD (67), cancer (43, 60), Type II Diabetes (61), obesity (61, 105), and mortality from all-causes (67). Furthermore, there is a dose response association between sitting time and risk of mortality, independent of leisure time physical activity and BMI (67). Additionally, evidence has suggested that sedentary time is strongly related to metabolic risk, independent of physical activity (8). Researchers concur that a growing body of evidence now implicates the risks of sedentary time and suggested that sedentary behavior should be constituted as an independent component of health (33).

Changes in our environment limit our physical activity but also require prolonged sitting; three primary domains of sedentary behavior have been identified including the workplace, leisure and transport (26). Sedentary behavior is most prominent in the workplace as working adults spend a significant amount of time sitting. According to the 2009 Bureau of Labor Statistics, adults spend approximately 8-9 hours of their working day sitting. Studies have demonstrated that working adults spend about one-half to one third of their workday engaging in sedentary behavior (64) and in some occupations, such as call center work can be as high as 90% (123). The latest study reported that sedentary time comprised of 77% of total work hours (122). Consequently, office-based workers are highly sedentary making them a key target group for an intervention to reduce sedentary behavior. As a result, the workplace is becoming a fertile environment to introduce strategies to reduce sitting time and break up periods of prolonged sitting to improve cardio-metabolic health (33).

Although workplace interventions targeting physical activity are common, research examining sedentary behavior as a primary outcome is limited. Height adjustable sit–stand desks are also more common in the workplace. Researchers have advocated the use of sit-stand desks to combat sedentary time, and interrupt prolonged sitting in the workplace (26, 87). Initially introduced in ergonomic research to reduce musculoskeletal injuries, sit-stand desks are now accepted as a practical and acceptable means of reducing sitting time. A pilot study by Alkhajah et al. (6) introduced a height adjustable sit-stand desk in the workplace as a method to reduce sedentary behavior. The results showed that sit-stand desks reduced sitting time by 137 minutes per day, and 78 minutes per day after 3 months. Sitting was almost exclusively replaced by standing and interrupted more frequently. Furthermore, the acceptance of the sit-stand desks is well-received and results in reduction of sitting time (6, 49). Reducing prolonged siting can potentially improve productivity (reduced absenteeism/presenteeism), and an increase postural variation is believed to improve work performance (119) and self-reported work productivity (56). A study conducted by Straker et al. (118) suggested that standing performance was not different from sitting, only mouse performance was affected. Additionally, research with a sit-stand intervention group resulted in a reduction in musculoskeletal complaints, without considerably affecting data entry efficiency, but a small trend toward decreased efficiency during standing was shown (62). A multi-component intervention “Stand Up, Sit Less, Move More,” conducted by Healy et al. resulted in no statistical significance in presenteeism or absenteeism (53).

Sleep is an important determinant for good health and overall well-being particularly in the workplace, as poor sleep can affect cognition, performance in an organization, in addition to individual health (88, 129, 120). Individuals who experience sleep problems reported lower levels of work satisfaction and had lower job performance scores (88); they were also at risk for a sleep disorder had increased presenteeism than not at-risk (120). Evidence has demonstrated that sleep disorders increase the likelihood of negative work outcomes, including occupational accidents, absenteeism and presenteeism (120). A study in Korea (2011), which investigated the relationship between sleep and work performance in a working population, found that the estimated cost of lost productivity time was greater in poor sleepers and had a higher annual cost due to presenteeism. Inadequate sleep can affect productivity, workplace injuries, absenteeism, and medical care expenditures (96).

Research examining the relationship between workplace sedentary behavior and its effects on work-related outcomes is limited. In fact, no studies to date have examined the association between a sedentary behavior intervention and work- related outcomes (productivity, presenteeism and cognition) as the primary outcome. Presently, a cluster-randomized controlled trial, “Stand Up Victoria,” seeks to evaluate the effectiveness of a multi-component intervention, featuring the installation of a height adjustable workstation and coaching, with the main objective of reducing sitting time, and secondarily assessing work-related outcomes (presenteeism, absenteeism, productivity and work performance).

The present study was introduced as part of a naturalistic environmental change in which university staff and faculty were relocated into a new building. As a result of the move, staff and faculty were given the option of a personal height adjustable workstation installed into their work area, in addition to three treadmill walking workstations which were placed in common areas of the work environment during the course of the study. A letter of support from leadership was emailed to staff during the first week of relocation to encourage the use of the sit-stand desk and treadmill workstation. The four month intervention period (July – October 2011) consisted of weekly emails based on Social Cognitive Theory constructs related to reducing sitting behaviors while increasing physical activity at work.

The objective of this study was to investigate the relationship between changes in sitting time, physical activity and sleep in a workplace environment change and its effects on work related outcomes: productivity, presenteeism and cognition (Figure 1). The primary aim is to test whether a workplace environmental intervention would affect work-related outcomes including i) productivity, ii) presenteeism and iii) cognition. The secondary aim is to examine whether work-related outcomes are correlated to observed changes in: i) sitting time; ii) physical activity, and iii) sleep. I hypothesize that intervention-related changes in sitting time, physical activity, and sleep will positively impact work related outcomes.

CHAPTER 2

LITERATURE REVIEW

Workplace Productivity

Productivity is defined as a measure of the amount of output generated per unit of input (81). Inputs are the amount of time and effort spent working, whereas outputs are the results. Logically, if the outputs are equivalent to the inputs, one is considered productive. Productivity is a term used to evaluate economic growth and competitiveness for many performance assessments. In the workplace, productivity is the driving force behind a company's success, growth and profitability. Productive workplaces are built on camaraderie, a shared vision, and a willingness to strive for success (HRINZ, 2011). However, many factors contribute to productivity. Employee well-being is one factor that is likely to influence productivity. Shi et al. (115) categorized 19 modifiable well-being risk factors in five dimensions (physical, health, social & emotional, work related, and financial risks). Among these, physical health and health risks have the highest impacts on productivity (115).

In a manufacturing industry, productivity is easily measured by the output, however evaluating productivity in an office-based setting can oftentimes be perplexing. Absenteeism and presenteeism, both major domains linked to productivity, can be affected by health risks (132). Absenteeism is an employee's time away from office related to medical absences, disability, or worker's compensation. The relationship between absenteeism and workplace productivity is an objective measurement, because costs associated with absenteeism has a causal effect on lost productivity. Examples of absenteeism include musculoskeletal disorders, cardiovascular conditions, mental health conditions, pregnancy, and family medical leave.

Presenteeism, on the other hand, is defined as "the percentage of time impaired while on the job (e.g., decreased productivity and below-normal work quality)" (99). It is the reduced ability to work productively due to a physical or health impairment. Presenteeism is measured as the costs associated with "reduced work output, error of the job, and failure to meet company production standards" (111). Examples of presenteeism include: musculoskeletal disorders, mental health concerns, respiratory conditions, gastrointestinal problems, migraine and obesity. Unlike absenteeism, it is difficult to objectively assess the impact of presenteeism especially in an office-based environment (22).

Measures of Absenteeism and Presenteeism

Absenteeism can be quantified as the total number of paid and unpaid sick days absent from work, also referred to as the absenteeism rate. A monetary amount can be calculated from the absenteeism rate into the cost resulting from absenteeism. However, there is considerable debate in the literature on how presenteeism should best be assessed. Commonly utilized and validated instruments to assess presenteeism include self-report measurement tools are the Work Productivity and Activity Impairment Questionnaire (WPAI), World Health Organization Health and Performance Questionnaire (HPQ), Endicott Work Productivity Scale (EWPS), Stanford Presenteeism Scale-6 (SPS-6), Health and Work Questionnaire (HWQ), and, Work Limitations Questionnaire (WLQ).

Work Productivity and Activity Impairment Questionnaire (WPAI)

Developed by Reilly Associates in 1993, the Work Productivity and Activity Impairment General Health (WPAI:GH) Questionnaire is a commonly used instrument to assess the relationship between health conditions and productivity at work. The WPAI:GH is a six question, self-reported measure with a recall time frame of 7 days. The questionnaire begins with questions related to employment status; then proceeds to evaluate work time missed as a result of health problem, the number of hours and minutes missed because of other reasons (e.g., vacation, holidays) and the number of hours and minutes actually worked. The last two question ask about how much health problems affect productivity while working; and how much health problems affect regular daily activities, using a 10 point scale from 0 (no effect on work) to 10 (health problems prevented the person from working). An advantage to the WPAI is the generalizability in measuring lost productivity across occupations and disease area (102). The instrument does not ask questions specific to the type of illness or type of employment and has been modified as a disease-specific instrument. Several versions of the questionnaire are available to include WPAI-general health (WPAI:GH), WPAI-specific health problem, WPAI-allergy specific, and the WPAI-gastro-oesophageal reflux disease, and WPAI-chronic hand dermatitis (83).

To date, the WPAI:GH has not been validated against other measures of productivity, but has been assessed for construct validity and reproducibility (102). Reilly and colleagues (106) sampled self- and interviewer-administered versions of the WPAI:GH in 106 employed individuals affected by a health problem. Construct validity of the WPAI measures were validated against measures of general health perceptions, physical and emotional pain, and work interference. . These validation measures explained 54 to 64% of variance (p less than 0.0001) in productivity and activity impairment variables of the WPAI. Although reproducible, self-administered version of the questionnaire had less construct validity than data collected by interviewer-administration. However, in a literature review, Prasad noted that the internal consistency reliability is not applicable for the WPA because the instrument is based on single construct, whereas the disease-specific versions had higher construct validity or test-retest reliability (102). A limitation to the WPAI is that it is restricted to a single construct of productivity at work or non-work hours, rather it should survey the impact on various tasks.

World Health Organization Health and Work Performance Questionnaire (HPQ)

World Health Organization Health and Work Performance Questionnaire (HPQ) is a self-report instrument designed to measure workplace costs. HPQ was created in collaboration with WHO as an expansion of WHO Disability Assessment Schedule (WHO-DAS). The HPQ was originally designed to measure employee productivity from an employer perspective. The questions are used to measure absence or reduced work productivity; however it does not address health-related productivity (102). The three outcomes measured are: absenteeism, job performance, and work-related injuries and accidents. Kessler et al. (69) administered the HPQ in four different employee populations: airline reservations agents, telecommunications customer service representatives, railroad engineers, and automobile manufacturing executives. Calibration data gathered from the HPQ survey was then compared with absenteeism data and job performance from employer records. Results from over 2000 participants found “good concordance between the HPQ and the archival data” across three of the populations (69). However, the instrument appears to be weak in predicting work performance among white-collar employees. A limitation to the HPQ is that it is not designed to assess performance in a specific area of performance, i.e. motor skills, concentration, attention to detail, etc. (102). Further research is needed to determine the instrument’s applicability and sensitivity in assessing work performance given interventions for a specific illness (102).

Endicott Work Productivity Scale (EWPS)

Another productivity scale, Endicott Work Productivity Scale (EWPS), is a 25-item questionnaire developed by Endicott and Nee (36) used to measure productivity over a range of medical conditions. The EWPS was developed to quantify the frequency of work performance and productivity attitudes and behaviors. The EWPS measures both absenteeism and presenteeism and was designed to capture lost productivity data within clinical trials (107). The instrument covers four domains: attendance, quality of work, performance capacity, and personal factors to include, social, mental, physical, and emotional. Each item captures the frequency of productivity-related behaviors during the past week, using a 5-point Likert scale. A sum of scores is then computed, with total EWPS scores ranging from 0 (best score) to 100 (worst score). The reliability and validity of EWPS has only been tested in patients with depression. Endicott and Nee (36) conducted a randomized study of depression scores with subjects with depression (psychiatric sample) and without depression (community sample). The psychiatric group EWPS scores were compared with the Hamilton Rating Scale for Depression (HAM-D) total scores, Global Clinical Index of Severity, Symptom Checklist (SCL)-90 total scores and Zimmerman total scores. Conversely, the EWPS total scores for the community sample were compared with SCL-90 and Zimmerman total scores. The data demonstrated that Test-retest reliability did not change between visits. Additionally the results demonstrated good test-retest reliability with an intra-class correlation coefficient for the total EWPS score was 0.9. Internal consistency was found to be 0.93 in the psychiatric sample and 0.92 in the community sample (Cronbach's alpha). As expected, the psychiatric patients had higher total EWPS scores (indicating reduced productivity) than their community counterparts. The content and criterion validity of the EWPS have not been assessed. However, the concurrent validity of the EWPS total score as a measure of the severity of illness was estimated by determining the extent to which the total score correlated with illness severity. According to the developer, up to one-third of items can be missing and replaced by the mean of the remaining items (12).

Stanford Presenteeism Scale (SPS-6)

One of the newer measurement tools used to estimate productivity loss is the Stanford Presenteeism Scale (SPS-6). Adapted from a 34 point scale (SPS-34) developed by researchers at Stanford University School of Medicine, the SPS-6 assesses the relationship between presenteeism, health issues, and productivity in the workplace. The six question instrument uses a Likert 5-item response scale based on a 1-month recall period to scale assess the ability to accomplish tasks and focus despite health impairment. The sum of the six items represents an overall presenteeism score (with a higher score indicating more presenteeism). Koopman et al. (74) investigated the concurrent validity, criterion validity and discriminant validity of the SPS-6 in a study of county health workers. The scale is proven to show strong internal validity, as it is negatively correlated with stress, and positively associated with job satisfaction (74). The SPS-6 overall presenteeism score demonstrated high internal consistency with a Cronbach's alpha of 0.80. The concurrent validity compared an individual's presenteeism score on the SPS-32 and SPS-6. The SPS-6 was significantly correlated with other measures of presenteeism. The criterion validity was compared SPS-6 scores to reports of work and non-work disability. However establishing the criterion validity was rather quite difficult, because disability does not directly imply productivity loss (83). Lastly, the discriminant validity measured whether presenteeism could be differentiated from other constructs such as job satisfaction and job stress. The SPS-6 score was weakly correlated with job satisfaction ($r = 0.15$) and job stress ($r = -0.22$) suggesting that presenteeism can be differentiated from the work constructs of job satisfaction and job stress. Overall, SPS-6 demonstrated excellent psychometric characteristics. A limitation was that the scale is unable to determine disease states, and the results cannot be directly converted to monetary units.

Evaluation of Objective Measures

Research efforts in evaluating health-related work productivity instruments has been inconsistent thus far; even to date productivity measurement tools are not fully developed. Each instrument has its own advantages for a specific population and health. While the outcome of some instruments translate to productivity losses in monetary terms, other reply on absenteeism and presenteeism data to determine the quantitative amount. In 2004, Prasad et al. (102) sought to validate work productivity instruments to better understand health impairment which leads to work impairment in the form of both absenteeism and presenteeism. Prasad and colleagues (102) identified six generic subjective instruments, the EWPS, HLQ, HWQ, HPQ, WLQ and WPAI. Previous to his research, these instruments were usually validated against other subjective measures (such as health-related surveys). Prasad (2004) suggested that WPAI and WLQ offered the greatest advantages for productivity outcomes. Although each productivity instrument has benefits in certain research settings, the psychometric properties of the WPAI have been assessed most extensively. It was the most frequently used instrument and has also been modified to measure productivity reductions associated with specific diseases (e.g. allergic rhinitis, gastro-esophageal reflux disease, chronic hand dermatitis).

Similarly, Lofland et al. (83) investigated health-related workplace productivity instruments. Reliability and validity testing have been performed for 8 of the 11 identified surveys. Of the 11 survey instruments identified, six capture metrics that are suitable for direct translation into a monetary figure. Of those six, the unnamed hepatitis instrument measures absenteeism only, and the other five, the Osterhaus technique, WPAI, HLQ, WPLQ and the WPI, measure both absenteeism and presenteeism. All of the identified instruments, except for the WPI, are available as paper, self-administered questionnaires; however, readers should note that instruments might be available in other modes of administration (i.e. the Internet) and did not conclusively prefer an instrument. Mattke et al. (86) reviewed 17 survey instruments that measure the effect of health on productivity, most of which had already undergone validity testing and widely accepted as reliable surveys. One notable instrument was the SPS-6, which exclusively addressed presenteeism. Unlike previous research, the finding of the study was specifically addressed measuring presenteeism. According to researchers, the most common approach to capture presenteeism is by assessing perceived impairment, they recommended instruments such as the HPQ, HWQ, SPS-6, WLQ, and WPAI. Secondarily when measuring comparative productivity, performance, and efficiency, researchers suggested the use of the HPQ and the HWQ. Finally, another method to quantify presenteeism is through cost estimation, although the reviewed surveys lacked an established and validated method to estimate the monetary costs of productivity loss.

Brown et al. (21) recently investigated the use of presenteeism measures in workplace physical activity and sedentary behavior research. Investigators reviewed eleven questionnaires and identified eight self-reported instruments that had undergone validity and reliability testing: WAI, EWPS, HLQ, HWQ, WLQ, WPSI, SPS-6, and HPQ. Six capture lost productivity suitable for direct translation into a monetary unit. Each of the instruments had their strengths: HWQ demonstrated good convergent validity, The EWPS had an ICC 0.92 over 14 day periods and WAI had a Cronbach's alpha of 0.72 over a 28 day period. Only 6 of the 11 instruments directly translated into a monetary outcome. Researchers concluded that HWQ, WAI, and WLQ are most suitable for evaluating the relationship between physical activity and presenteeism. However, when measuring work performance, the EWPS, HWQ and SLQ were advisable.

Health Risks

A health risk is any factor that can impact one's health. In the workplace, Health Risk Assessments (HRA) are widely used as a screening tool to determine one's health status. The term health risk assessment is often used interchangeably with health risk appraisal. The Centers for Medicare and Medicaid describes HRA as "a systematic approach to collecting information from individuals that identifies risk factors, provides individualized feedback, and links the person with at least one intervention to promote health, sustain function and/or prevent disease. HRAs can be used effectively to identify health risk factors, estimate health related costs and measure absenteeism and presenteeism (99).

There is no universal standard for HRA assessment; however, most questionnaires capture information related to demographic characteristics, lifestyle (e.g., smoking, exercise, alcohol consumption, diet), personal and family medical history, and physiological data (e.g., height, weight, blood pressure, lipid profile). Health risk assessments are repeated yearly to provide workplace wellness programming information. Workplace productivity measures are frequently found in a HRA.

Definition of Health Risks

The National Committee for Quality Assurance (NCQA) is a non-profit organization in the United States designed to improve health care quality. The NCQA certifies HRA and defines the criteria for each risk categorization. Alcohol risk is defined a positive CAGE questionnaire, a four questionnaire instrument used to screen as an alcohol screening test. Emotional health is determined by moderate to high stress levels, or depression levels, which interfere with one's job or personal life. Nutrition risk is defined as a medium to very high daily dietary fat intake, or consumption of less than five servings of fruits and vegetables. Physical inactivity risks are present with less than 30 minutes of moderate activity, 5 days a week, or less than 60 minutes of vigorous activity per week. Safety risk is defined as failure to meet basic safety requirements. Blood pressure risks is present with diagnosed hypertension of blood pressure values reported greater than or equal to 120/80 mmHG. Blood glucose risk is present with diagnosed diabetes or fasting blood glucose values greater than or equal to 100 mg/DL or non-fasting glucose values greater than or equal to 140 mg/dL. Cholesterol risk is defined as LDL cholesterol values greater than 100 mg/DL or LDL cholesterol values greater than 130 mg/dL, or total cholesterol values greater than 200 mg/dL. Triglycerides risk is defined as fasting triglycerides values greater than 150 mg/dL. Weight risk is present when BMI is less than 18.5 kg/m^2 or greater than or equal to 25 18.5 $kg/m^{2.}$ Tobacco risk is present with use of any tobacco product (smoke, chew, snuff, cigars, and pipes) (45).

Health Risks and Productivity

Studies, thus far have revealed a strong relationship between health risk statuses, work related costs and productivity outcomes. Goetzel et al. surmised that reducing health risks may be a practical way to improve productivity outcomes (45). The Health Enhancement Research Study (HERO) (1998), one of the largest studies to date, estimated the impact of ten modifiable health risk behaviors on health care expenditure. Collecting HRA data from 46,026 employees and analyzing each health risk using multivariate regression models, results showed that high risk employees had significant costlier medical expenses than those at lower risks. This study was the first to demonstrate the costs of mental health related issues on employee health. Depression was found to have the highest impact (70% higher expenditures), followed by stress (46%), high blood glucose levels (35%), body weight (21%), tobacco users (20% for former, 14% for current users), high blood pressures (12%) and a sedentary lifestyle (10%). Employees with a cluster of health risks had higher expenditures than those without the risk factors. Investigators concluded that modifiable health risks are associated with increased health expenditure. To further the research, in 2000, Goetzel and colleagues examined the impact of health risks on medical costs, and discovered that 25% of total expenditures were associated to same ten risk factors (44).

Goetzel's research pioneered future research in evaluating the association between health risks, and absenteeism and presenteeism. The earlier studies established a substantial link between behavioral health risk and absenteeism, in addition to a reduction in health risks and a reduction in absenteeism. In 2001, Serxner and colleagues (114) from the StayWell Company investigated the relationship between behavioral health risks and workers absenteeism and found that individuals who are at risk are more likely to be absent that individuals at lower risks. The results indicated that a strong relationship between health risks and absenteeism exists in 8 of the 10 risk categories (excluding alcohol use and self-care). Using a regression model, the relationship between health risks and absenteeism and changes in health risks and absenteeism was analyzed. Results demonstrated that individuals who reduced their mental health risk were 1 1/3 less likely to be absent, than their at-risk counterparts. At risk individuals who lowered their number of risks were 1.25 times as likely to be less absent in comparison to at-risk individual who did not lower their risks. The data from this study demonstrated significant impact between changes in mental health on absenteeism. Research has consistently proven a linear relationship between the number of health risks and productivity loss. Employees with 3 or more risk factors were likely to have higher levels of absenteeism (125). Boles et al. also suggested that employees who have more health risks experienced absenteeism and presenteeism than employees with fewer risks (15).

Changes in Health Risks and Productivity

While a cluster of health risks have been shown to be associated with detrimental to employee health and workplace productivity, reductions in health risks have led to positive changes in worker productivity. In 2004, Pelletier et al. (99) examined the association between changes in health risk and changes in work productivity using a HRA with a WPAI:GH Questionnaire, a scale used to assess the relationship between health conditions and productivity at work for 500 employees at two time points. After a one year period, the evidence suggested that individuals who reduced one health risk improved their presenteeism by 9% and reduced absenteeism by 2%, after controlling for demographic variances. Parallel to previous research, the prevalent risk factors such as high stress, lack of emotional fulfillment, and diabetes reported 14-15% productivity loss.

Comparably, Burton et al. (22) examined the impact of employee health risk factors on self-reported worker productivity (presenteeism) using a modified version of the Health Risk Appraisal with 8 questions from the Work Limitations Questionnaire (WLQ). Based on 12 health risk factors, high risk individuals (excluding alcohol and cholesterol use) have excess productivity loss than low-risk individuals. Ten of 12 health risk factors (excluding alcohol and cholesterol) studied was significantly associated with self-reported work limitations. As the number of self-reported health risk factors increased, so did the percentage of employees reporting work limitations. Individuals with zero risk factors had an estimated productivity loss of 11.9%, and each additional risk factor was associated with 2.4% excess productivity reduction. Medium and high-risk individuals were 6.2% and 12.2% less productive than low-risk individuals, respectively. Once again, the perception-related risks highly correlated with lost productivity pertained to relaxation medication, life dissatisfaction and high stress, showed the greatest association with presenteeism. As a continuation from the previous prospective study of 7000 employees, Burton et al. (22) investigated the changes in health risks associated with the changes in presenteeism using a modified version of WLQ in 2002 and 2004. Evidence suggested a linear relationship between risk change and presenteeism change. Individuals who reduced their health risks saw an improvement in productivity, whereas those who increased health risks saw deterioration in productivity. There was a 1.9% change in self-reported productivity loss for each risk factor changed.

Mental Health Risks and Productivity

According to a recent survey of large companies by the Institute of Health and Productivity Management, mental health conditions are top rated reason for lost productivity at work and the second is absenteeism. Stress can be defined as the brain's response to any demand. Stress can affect both mental and physical health. Stress at work can arguably be the greatest cause of occupational disease (77) and can have detrimental consequences for both the employee and employer. Stress is a contributor to a variety of health issues including “coronary heart disease, cancer, diabetes, bacterial and viral infections and depression” (4).

Evidence has demonstrated a well-established link between stress and absenteeism (4). The Commerce Clearing House Incorporated predicted that stress is contributes to approximately 14% of absenteeism in the United States. Sinha (117) investigated the relationship between stress and absenteeism and discovered a low to moderate relationship between stress and absenteeism. Jacobson et al. (63) found that stressed employees were 2.22 times more likely to be absent for 5 or more days, in comparison to low stressed individuals. Likewise, Boles et al. (15) also conveyed that high levels of stress resulted in 1% loss of work hours due to absenteeism.

In congruence with past studies, Stress was also found to be an explanatory variable for increased presenteeism, with a decrease in presenteeism level of 10% for high levels of stress, compared to 5% reported by lower stress (15). A strong association between presenteeism and stress was reported in an Australian study, higher stress individuals were more likely to have increased presenteeism levels of 26.6%, in comparison with 14.7% with lower stress (90).

Lifestyle Risk Factors and Productivity

Smoking

Smoking is not only deleterious to health, research indicates that smoking has detrimental consequences to productivity in the workplace. Consistent evidence supports the strong association smoking has on absenteeism and presenteeism measures. For instance, Halpern et al. (50) investigated the difference between current, past and never smokers. This study demonstrated than current smokers had a substantial increase in absent days (4 days) than both former smokers (2.4 days) and never smokers (1.33 days). When Tsai et al. (125) compared absenteeism rates for a number of health risks, researchers found that smoking status was the second most influential factors in terms of days absent. Bunn et al. found similar results with a significant difference between smokers (4.9 day per year) and nonsmokers (4.4 days per year). In the most recent study conducted by Williden et al. (132) smokers were associated with an additional 11.6 hours of absenteeism compared with nonsmokers over a 4 week period. This finding concurs with previous research that smokers tend to have a higher morbidity rate with chronic conditions and greater risks for developing nonfatal CVD that contribute to greater absenteeism. A new finding from Williden's study revealed that quitting smoking may reduce absenteeism and reduce costs for employers. In a systematic review conducted by Weng et al. (134) smoking increased the risk and duration of absenteeism. Current smokers were 33% more likely to be absent than non-smokers. To date, there is not an abundance of evidence linking smoking and presenteeism, although Merrill et al. (89) suggested that "smoking may be positively associated with presenteeism independently or because of its association with poor nutrition, less physical activity and worse general physical health."

Physical Activity and Productivity

According to World Health Organization (WHO), physical activity is "defined as any bodily movement produced by skeletal muscles that require energy expenditure". Physical activity can be classified light intensity (1.1 MET to 2.9 METs), moderate intensity (3.0 to 5.9) or vigorous intensity (6.0 METs or more). The recommended physical activity guideline for Americans adults is at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity per week. Not meeting the recommended guidelines is defined as physical inactivity, which has been identified as a considerable risk factor for global mortality causing an estimated 3.2 million deaths globally (103). Regular physical activity has proven significant benefits for health; physical activity can reduce the risk of cardiovascular diseases, diabetes, colon and breast cancer, depression, and longevity (103).

The association between physical activity and productivity is not clearly established. Earlier studies have not found a positive relationship between physical activity and productivity. One of the first studies conducted by Bertera et al. (13), evaluating the impact of behavioral risk factors on absenteeism, found that employee physical inactivity was not associated with high levels of absenteeism. Yen et al. (135) analyzed absenteeism using a regression model to determine health risks and predictors, and found that physical activity participation was not influential factor. Furthermore, Burton et al. (23) did not show a difference between sedentary employees and active employees with respect to rates of absenteeism. Aldana and Pronk (4) verified the same findings with a meta-analysis investigating the impact of physical activity on absenteeism. Researchers concluded that although high levels of fitness should translate in the reduced incidence of chronic diseases; this did not demonstrate lower levels of absenteeism (4). They found that there was not a significant correlation between fitness levels and absenteeism.

On the other hand, several studies have reported that physical activity is related to absenteeism. Employees who are likely to exercise are less likely to incur absences. In particular, Jacobson and Aldana (63) investigated the frequency of aerobic exercise with absenteeism using a health profile questionnaire, and examining exercise habits. They reported a significant relationship between the number of days of exercise and absenteeism. The frequency of exercise reported per week is associated with less absenteeism (63).

Current research is now demonstrating a shift of prevalent health risks with productivity. Goetzel et al. (46) revisited the data of the HERO study to analyze the changes over time. In comparing the results from the original HERO study, the risk profile of American workers changed over time. In 1998, depression was the most important predictor, followed by high stress, and obesity. However in 2012, physical inactivity was mentioned as a considerable predictor of health risks, 15.3% to 10.4% previously. Concurrently, a systematic review conducted by Lenneman et al. (78), examined the effectiveness of workplace health promotion program in improving presenteeism, and identified successful components of health promotion programs and the risks factors for presenteeism. Their findings suggested that exercise is beneficial in improving presenteeism. Lenneman et al. (78) uncovered that the prevalence rate of physical activity was 43.6%, in comparison to 8.4% for depression, when examining productivity and health status from three perspectives. Researchers concluded that "physical inactivity is shown to be nearly 62% more costly than depression."

In a meta-analysis review of 20 articles, Brown et al. (19) examined the relationship between physical activity and employee well-being and presenteeism in the workplace. Their investigation demonstrated a positive association between physical activity and psychosocial health in employees, especially for quality of life and emotional well-being. However there was limited evidence between physical activity and presenteeism. Researchers inferred that since physical activity is an influential force in lower body weight, managing stress, hence it should also decrease presenteeism (24).

When investigating the association between health risk factors, absenteeism and presenteeism in the New Zealand workforce, Williden et al. (132) examined whether the numbers of health risks are associated with increased absenteeism or reduced work productivity using the HPQ. Results illustrated that meeting physical activity guidelines improved productivity by 3.44%. However one of the major limitations to this study was that the New Zealand Physical Activity Guidelines requires at least 30 minutes of moderate to vigorous physical activity each day on greater than/equal to 5 days, varying from the current American College of Sports Medicine Guidelines.

Physiological Health Risks and Productivity

Metabolic Risk Factors

Metabolic risk factors consist of elevated cholesterol levels (triglycerides, LDL), high blood pressure, high glucose levels, and obesity. In 2009, Schultz et al. (112) identified risks of metabolic syndrome (MS) in a manufacturing company using data from 2006 HRA with WLQ integrated, and biometric screening data. Researchers also examined the association between the economic costs (health care costs short term disability absenteeism and on the job productivity loss) and MS risks. Results proved that 36.6% of employee had high pressure or have used blood pressure medications, 32% high BMI over 30, 32% had fasting glucose of greater than 100 or reported taking medications, 33.1% had low HDL-C or reported taking medications, 42.2% met criteria for high triglycerides. 30.2% of employee population met the criteria for MS. Their finding demonstrated that higher levels of presenteeism were associated with higher number of risk factors.

Obesity

Studies have consistently found that excessive body weight has a strong correlation with elevated levels of absenteeism (4). Obese employees had 11% higher rate of absenteeism than non-obese (13). Obese employees were 1.74 and 1.61 times more likely to experience high and moderate levels of absenteeism, respectively than their lean counterparts (126). Burton et al. (22) found that obese workers were 1.5% less productive than non-obese workers. Similarly, Trogdon et al. (124) studied the relationship between obesity and indirect (non-medical) costs. The review suggested that obesity has a negative impact on workplace productivity.

When exploring the relationship between overweight, obesity and presenteeism in Belgium, investigators (17) collected sick absence data from 2,983 employees. This study, consistent with previous studies indicated that overweight and obesity is significantly related to a productivity loss. The results demonstrated a positive relationship between BMI class and presenteeism. Because overweight and obese women and overweight men were more likely to be absent, they reported more presenteeism than their normal weight counterparts. A limitation to this study was that presenteeism was measured based on a single question that assessed how often employee came to work despite feeling ill. Additionally, those in the overweight and obese body mass index (BMI) ranges and those with health risks (high blood pressure, high cholesterol, diabetes, depression, heart attack, asthma, and musculoskeletal disorders) were significantly associated with a greater risk of a presenteeism score (89).

Evidence has shown that obese females in particular, have a higher absenteeism rate than non-obese female subjects (4). Obese female subjects were 1.5-1.9 times more likely to be absent of sick leave than non-obese (92). 10% of loss of productivity due to sick leave and disability among female subjects may be related to obesity (92). Obese female subjects had a twice as likely in absenteeism when compare to non-obese and had incurred absenteeism related costs 178% greater than non-obese (125). Obese male employees reported less absenteeism than females, and incurred absenteeism related costs

34% more than non-obese (125). Comparably, presenteeism was reported by 51% of the female population, which was higher than the male (17).

The significant relationship between productivity loss and obesity may be due to obesity related diseases, such as CVD, diabetes, and certain cancers. Obese individuals may have greater rates of disease, which results in higher rates of absenteeism (4). Weight loss, however can improve productivity. Bilger et al. (14) examined the effect of weight loss among overweight employees on health, productivity and medical expenditures. The study identified groups of employees that achieved ≥5% weight loss (treated) or no weight loss (control). The outcome variables measured the medical expenditures, absenteeism, and presenteeism using the SPS-6. The results supported statistically significant evidence that ≥5% weight loss reduces absenteeism by 0.258 days/month, prevents presenteeism. Employee productivity can be improved when a ≥5% weight loss is achieved (14).

Hypertension, Hyperlipidemia, & High Blood Glucose and Productivity

Although hyperlipidemia and hypertension are major risk factors for cardiovascular disease, the link between these risk factors and absenteeism is inconsistent (4). The correlation between hyperlipidemia and hypertension and absenteeism has not been well studied. Yen et al. (135) found that hyperlipidemia or hypertension was not a predictor of absenteeism. Burton et al. (23) also agreed that hypertension was not significant in absenteeism rates. The majority of studies to date rated no difference in absenteeism between normotensive and hypertensive adults (4).

In contrast, Bertera et al. (13) found that hypertensive employees had 11% higher incidence of absenteeism than employees who were normotensive. Researchers also found that employees with high cholesterol levels had an 11% higher absenteeism rate than employees with lower cholesterol levels. Additional, Goetzel's HERO research found that high cholesterol was highly correlated with health care costs (45, 46).

There has not been sufficient evidence linking elevated blood glucose with impaired work productivity. Although high blood glucose is strongly related to increased health care costs by 31% (46), decreasing the risk for glucose levels has not resulted in any significant change to productivity impairment levels (78). Nonetheless a strong association linking the incidence of diabetes and productivity has been correlated with work impairments, limitations and absenteeism (18).

Cognition

Cognition, the "process of thought," is a group of mental processes that mostly occurs in the pre-frontal cortex of their brain and is a crucial mechanism for healthy individuals to learn a new skill set. Cognitive executive function is often used as an umbrella term for cognitive abilities that "regulate, control, and manage processes such as planning, working, memory, attention, problem solving, verbal reasoning, multi-tasking, and monitoring of actions among others" (25). Factors such as aging and disease can impair cognitive function, while research has demonstrated that exercise can significantly improve cognitive functioning (58).

Cognition and Physical Activity

Sufficient evidence has suggested that physical activity is an integral element in promoting healthy and effective cognitive functioning (68). Colcombe and Kramer (71) conducted a meta-analysis to investigate the effects of aerobic fitness training on cognitive functioning of healthy but sedentary older adults. Interventions varied from a wide range of activities and were categorized into the aerobic group, or combination group (cardiovascular training with strength training). The findings suggests that executive control processes benefited most from improved fitness, and enhance cognitive vitality of older adults. Investigators stated that the improvement in cognition was mediated by neural activation changes. Similarly, exercise-cognition based intervention in older adults also demonstrates a reduced risk for "age-associated neurodegenerative disorders, such as Alzheimer's disease and vascular dementia" (57).

The effects of physical activity on cognition with children have been widely studied and indicate that school aged children who are physically active are more likely to increase academic performance (57). A meta-analysis by (116) demonstrated a positive correlation between physical activity and cognition in eight measurement categories, such as IQ, perceptual skills, verbal and mathematic tests, academic readiness, with the exception of memory. Investigators noted a stronger effect of physical activity on younger children (4-7 years and 11-13 years), in comparison to older children (8-10 years and 14-18 years).

A growing body of literature has linked physical activity with improvements in brain function at the molecular, cellular, systems and behavioral levels (57). Hillman and colleagues (58) examined effects of acute cardiovascular exercise on cognitive function in 20 undergraduate students. The participants completed an Ericksen Flanker task followed by a graded maximal exercise test. After each 30 minute bout of exercise, another Ericksen Flankers Test was given until heart rate returned to within 10% of pre-exercise levels. The findings suggest that acute bouts of cardiovascular exercise affect "neuroelectric processes underlying executive control through the increased allocation of neuroelectric resources and through changes in cognitive processing and stimulus classification speed" (58).

Cognition and Posture

Current literature suggest that there are no significant difference in cognitive performance among common postural allocations: sitting, standing and walking. For instance, Straker et al. (118) investigated the effects of a six workstation conditions (traditional sitting, standing, cycling at 30 watts, cycling at 5 watts, walking at 1.6 km/h and walking at 3.2 km/h) on cognitive functioning tasks such as speed and error during typing, mouse pointing, and combined type and mouse-use tasks. Results proved that speed and accuracy on computer related tasks were impaired when walking and slightly lower when cycling in compared to sitting. Standing performance was not different from sitting performance; there was no difference in typing performance and perception (118). This study was one of the first to confirm that the standing workstation design did not impair performance. Additionally, the qualitative reports suggested that participants gained cognitive benefits from using the treadmill desk because it broke up the monotony of the office work.

Most recently, Alderman et al. (5) examined the executive function during low intensity walking using Stroop and Ericksen Flanker Tests. Sixty six college students participated in a crossover design (one session was seated, while the other was low intensity walking on the treadmill). After a preparatory phase on the treadmill workstation (15 minutes), participants completed the cognitive tests. The results revealed that low intensity treadmill walking did not impair cognitive abilities, nor did it affect work productivity. Again, there was no significance between conditions observed for any of the cognitive tests.

On the other hand, there have been studies that demonstrated the position does have an effect on certain domains of cognitive processing. For instance, Andersen et al. (7) tested whether postural allocation has a significant effect on domains of cognitive functioning. Investigators used the CNS Vital Signs (CNSVS) test battery to assess neurocognitive function for two conditions (sitting and standing). Evidence demonstrated that position did have an effect on domains of cognitive performance. Of those domains tested, results proved that complex attention tasks were significantly better sitting than standing; position does not affect the other tested domains of cognitive performance. Interestingly, researchers created a make shift stand desk with two stacked boxes on top of a table and used a laptop computer to assess measurement.

Similarly John et al. (65) assessed the differences between seated and walking conditions on motor skills and cognitive function tests; they found that the seated condition produced significantly better results. Computer typing, mouse proficiency, the Stroop Color and Word Test, versions of the GRE math and reading were administered seated and while on the treadmill workstation at 1mph. Results demonstrated impaired performance on typing, mouse proficiency, and GRE math tasks, but no significance on reading comprehension or Stroop Color and Word Test while walking. There were no significant differences between the two conditions in selective attention and processing speed or in reading comprehension. A limitation to this study was that participants were not given sufficient time to acclimate to the treadmill, or select their preferred walking speed.

Cognitive Measures

Cogstate is widely accepted computerized cognitive test used to measure cognition in research studies, clinical trial, and experiments. This computerized test is proven to be valid and reliable in many research and social settings (29). The battery of tests is used to identity and measure cognitive impairment. The batteries of tests monitor cognitive change and includes measurements of “visuomotor function, psychomotor/processing speed, visual attention/vigilance, attention/working memory, verbal learning and memory, executive function, and social cognition” (29).

Cogstate tests are commonly used in treating cognitive impairment in mental conditions, such as schizophrenia, depression, dementia, and ADHD. In particular, this test has demonstrated sensitivity to drug related changes in cognition (85). Paul Maruff and colleagues (85) examined the validity of processing speed, attention working memory and learning within the Cognitive battery. The construct validity was determined with a large group of healthy adults and the criterion validity was determined with a group of individuals with mild head injury, schizophrenia, and AIDS dementia complex. The Cogstate battery suitably defined cognitive paradigms and was found to have acceptable construct (r=.49 to .83) and criterion validity (Cohen’s d’s = -.60 to -1.80). Additionally, Pietrzak et al. (101) examined the criterion and construct validity of Cogstate to the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) consensus for a schizophrenic population Moderate to large correlations were observed between The correlation between Cogstate and MATRICS was observed between r’s =0.56 – 0.79. The results suggest that the Cogstate Battery provides valid measurement for cognitive impairment in schizophrenia.

Sedentary Behavior

Environmental and societal changes within the past 50 years have attributed to prolonged sitting which is now a problematic concern due to the deleterious health consequences. Changes in our environment limit our physical activity but also require prolonged sitting; three domains of sedentary behavior have been identified in the workplace, leisure and transport (26). Sedentary behavior, or too much sitting, refers to "waking activity characterized by an energy expenditure of ≤ 1.5 METS and a sitting or reclining position" (113) and includes activities such as sitting, lying down, and watching television (98). The 2003-2006 National Health and Nutrition Examination Survey (NHANES) data identified that 51-68% of adults' total waking hours are spent sedentary (54). Sedentary behavior is distinct from sleep due to the "physiological restorative functions", and accounts for behaviors that occur during waking hours (103). Sedentary behavior is also independent of exercise and physical inactivity (95). There is now a clear distinction between sedentary behavior and physical inactivity as the benefits of physical activity are offset by the amount of time spent sitting (95). Even among the most physically active individuals, high amounts of sedentary time cannot be counterbalanced.

Sedentary Behavior and Health Risks

The health risks associated with sedentary behavior are now becoming evident. Research indicates that sedentary behavior is a distinct risk factor for multiple health outcomes, such as chronic health condition such as CVD (67), cancer (43, 60), Type II Diabetes (61), obesity (61, 105), and mortality from all-causes (67). Furthermore, there is a dose response association between sitting time and risk of mortality, independent of leisure time physical activity and BMI (67). Additionally, evidence has suggested that sedentary time is strongly related to metabolic risk, independent of physical activity (8). In 2012, Dunstan and colleagues explored evidence from experimental and epidemiological studies pertaining to sedentary time as a modifiable health risk. Sufficient evidence implicates the risks of sedentary time and should be constituted as an independent component of health (33). Additionally, global physical activity guidelines need to make specific recommendations around sitting (33). Investigators further state that healthcare practice should take a role in advising patients to reduce sitting time while increasing light intensity physical activity.

On the other hand, a systematic review conducted by Van Ufflen (130) examining the relationship between occupational sitting and health risks, concluded that there is only limited evidence in support of a positive relationship between occupational sitting and health risks. When further researching each health risk, investigators found a positive association between occupation sitting and BMI and Type 2 Diabetes. However the association between sedentary behavior and CVD and cancer risks showed conflicting results (130). Researchers did however conclude that the majority of the studies found that sitting was associated with an increased mortality risk. (130)

Sedentary Behavior Physiology

Sedentary behavior has proven to have deleteriously biological consequences. Too much sitting can cause the disengagement of the postural muscles in the legs, back and neck. These muscles play an integral part in maintaining posture during standing or light exercise, and are crucial in processing fat and cholesterol (51). Specifically, lipoprotein lipase, which is related to cardiovascular risk, is most affected. Lipoprotein lipase (LPL) is an enzyme important for the transfer and breakdown of triglycerides from lipoproteins to fatty acids and monoglycerides, which then is transported into tissues for fuel or storage. Lipoproteins can be regulated by physical activity, and have high sensitivity to inactivity. It has been suggested that prolonged sitting can lead to loss of local contractile stimulation, which leads to the compression of skeletal muscle LPL activity and reduced glucose uptake through the translocation of GLUT-4 glucose transporters to the skeletal muscle (51). The reduced clearance of an oral glucose load from plasma and less glucose then stimulates insulin secretion (51). As a result, overall sedentary time is associated with central adiposity (larger waist circumference), increased triglycerides levels, and insulin resistance, all of which are independent of total exercise time.

Sedentary Breaks

Prolonged sitting without breaks is a contributor to poor health. A growing body of literature has linked uninterrupted sedentary time with poorer cardio-metabolic health profiles than those who engaged in frequent breaks (55). In an Australian Diabetes, Obesity and Lifestyle study (AusDiab Study) conducted by Healy et al., (55) researchers examined the association between breaks in sedentary time and metabolic risk factors. Participants wore an accelerometer, Actigraph, for seven consecutive days during waking works. An interruption of ≥100 counts/minute was considered a sedentary break. In addition to monitoring sedentary time and breaks, cardio-metabolic biomarkers was measured at pre and post-test. The results proved that increased breaks were positively associated with metabolic risk factors, waist circumference measures, triglycerides and 2-h plasma glucose. The study confirmed that more interruption in sedentary time is positively associated with metabolic risk variables, independent of total sedentary time, moderate to vigorous intensity time, and the intensity of breaks (55). This study recommended the importance of breaking up sedentary time. Prolonged sitting has been linked with less healthy metabolic profiles compared to interrupt sitting (55).

More recently, Dunstan and colleagues (33) researched the acute effects of uninterrupted sitting in overweight middle-aged adults on postprandial plasma glucose and serum insulin. The study design was a crossover condition where each participant completed a condition over a 7 hour period in a randomized order: (1) uninterrupted sitting (2) interrupted sitting with light intensity treadmill walking (3.2km/h) for 2 minutes every 20 minutes, and (3) interrupted sitting with moderate intensity treadmill walking (5.8-6.4 km/h) for 2 minutes every 20 minutes. Glucose was reduced by 24% in the light activity break condition, and 30% in the moderate condition. Insulin was reduced by 23% after the activity-break than in uninterrupted sitting (33). There was no statistical significance between the two activity groups in the glucose and insulin.

Measuring Sedentary Behavior via Self-Report

Physical activity and sedentary behavior can be assessed using self-reported (questionnaires, activity logs, etc.) or objective measures (accelerometers, inclinometers, etc.). For population studies, self-report questionnaires are used to assess type of activities performed utilizing a recall time. Self-report instruments include the International Physical Activity Questionnaire (IPAQ), Occupation Sitting and Physical Activity Questionnaire (OSPAQ), and Australian Sedentary Behavior Questionnaire (ASBQ).

Tested for validity and reliability in twenty countries, the IPAQ was developed as an instrument to monitor physical activity and inactivity. The IPAQ evaluates leisure time physical activity, domestics and gardening activities, work related activity and transport-related physical activity. With a recall period of 7 days, there are two versions of the IPAQ, the short and long forms. Craig et al. (30) assessed test-retest, concurrent validity and criterion validity against the MTI accelerometer. The findings produced a Spearman correlation coefficient of p= 0.80, concurrent validity of r= 0.67, and criterion validity of r=0.30. Researchers noted that the IPAQ could confidently monitor population levels of physical activity among adults in diverse settings.

The OSPAQ is one of the few instruments that measures occupational sitting and physical activity. The instruments asks about the number of hours worked and the number of days at work within the past 7 days. The questionnaire asks to self-report typical work days into percentages of: sitting (including driving), standing, walking and heavy labor or physical demanding work. Chau and colleagues (27) sought to validate the measure of OSPAQ against sedentary time, light-moderate-vigorous activity with an ActiGraph GT1M accelerometer. The test–retest intraclass correlation coefficients for occupational sitting, standing, and walking for OSPAQ ranged from 0.73 to 0.90. When testing the criterion validity against the ActiGraph GTM1M, the OSPAQ showed a Spearman correlation of r=0.65, r=0.49 and r=0.29 for sitting, standing, and walking, respectively. Researchers suggested that the OSPAQ has excellent test–retest reliability and moderate validity for estimating time spent sitting and standing at work.

Finally, the ASBQ is a 7-item instrument which measures sedentary time in various domains within the last week. The questionnaire asks to determine how much times was spent sitting or lying down with activities such: television viewing, computer/internet, reading, socializing with friends, driving, doing hobbies, and doing any other activities. Test-retest reliability, validity and responsiveness to change were measured in an older adult population of a sedentary behavior intervention. The reliability of the instrument was measured at two time points: before the intervention (T1) and during the intervention (T2). The validity of the instrument was measured against an accelerometer (ActiGraph model GT1M). The responsiveness to change was measured post-intervention (T3) and (T2). The test-retest reliability of total sedentary time was Intraclass correlation coefficient (ICC) was r=0.52, validity was r=0.30, and responsiveness to change was r=0.47. The ASBQ demonstrated good repeatability, modest validity and sufficient responsiveness to change (40).

Objectively Measuring Sedentary Behavior

Recent technology has provided accurate measurement of physical activity and sedentary behavior quantification and can differentiate between specific behaviors (sitting, standing or walking). The objective measurements can quantify the amount of physical activity, the intensity of physical activity, estimate energy expenditure and amount of sedentary time, thus making it a more valid measure. A commonly used physical activity monitoring device to assess sitting time in research is the activPAL (PAL Technologies, LTD, Glasgow, UK). The activPAL is a tri-axial accelerometer that can measure postural allocation (sitting, standing, lying down or walking). Multiple research efforts have suggested the reliability and validity of the activPAL3 consistently in both laboratory and free living conditions. Ryan et al. (109) examined twenty healthy adults walking indoors on a treadmill at five different speeds, and outdoors at selfselected slow, normal, and fast speeds. Comparing the activPAL step count and cadence output to video observation, Ryan and colleagues (109) confirmed the validity of the device as <1.11% for both steps and cadence regardless of walking speed. Concurrently, the accuracy of two commonly used pedometers, the Yamax Digi-Walker SW-200 and the Omron HJ-109-E, was compared to observation for measuring step number. At all speeds, the inter device reliability of the activPAL was r >0.99 for both steps taken and cadence. Investigators concluded that activPAL monitor is a valid and reliable measure of walking in healthy adults, and its accuracy is not influenced by walking speed.

Similarly, an investigation by Grant et al. (48) examined the validity and reliability of the activPAL in a simulated free-living condition. Ten healthy participants were randomly assigned to perform two types of activities (controlled and activities of daily living) while wearing three activPAL monitors (mid- thigh, immediately distally and on top of the distal monitor). The controlled group consisted of sitting, standing, and walking for two to nine minutes each. The activities of daily living group consisted of six everyday activities such as sitting, standing, and stepping. Additionally participants were randomly assigned to 19 activities (e.g., doing laundry, cleaning, computer use, etc.). Observation analysis and video recordings were the criterion standard which was then compared to activPAL output. When compared to the criterion measure, the activPAL demonstrated excellent percentage agreement for the sitting (0.19%), and standing (-0.27%), and stepping (-2.0%) tasks in both the controlled and activities of daily life sections. The different monitors also demonstrated strong reliability among each other for sitting, standing, and stepping (ICC) r=0.79 to 0.99). The observation analysis and monitor found an overall agreement of 95.9%. The experiment suggested that activPAL activity monitor is a valid and reliable measure of posture and motion during every day physical activities.

In Arizona (2) a study was conducted to examine the validated objective measures of sedentary behavior and physical activity (ActiGraph and activPAL) to the subject measurement of a PA log, the Bouchard Activity Record (BAR). Thirty two healthy adults were recruited to wear both devices and completed the BAR while performing their daily activities. Sedentary behavior and physical activity was analyzed between all instruments. The data found a significant difference in both sedentary time and physical activity between ActiGraph and activPAL, and ActiGraph and BAR. Additionally, The BAR detected less time in sedentary behavior than both activPAL and ActiGraph. Overall both the activPAL and BAR similarly detected sedentary time and physical activity. Researchers suggested that the activPAL is a valid measure of both sedentary time and physical activity, and the BAR was shown to have a high convergence with the activPAL.

Kosey-Keadle et al. (73) investigated the association between sedentary behavior and wearable monitors in a free-living environment. Twelve overweight, inactive office workers wore both the activPAL and Actigraph GT3x for two 6-hours period. Investigators tested the validity of both devices using the criterion measure of direct observation to record five activity categories (lying, sitting, standing still, standing still with upper body movement, standing/moving, moving moderate and moving vigorous).The results demonstrated that the activPAL and the Actigraph GT3x underestimated sitting time by 2.8% and 4.9%, respectively. The results showed a strong correlation in sedentary minutes between the activPAL and direct observation was R^2=

0.94, whereas the Actigraph R^2= 0.39. Ultimately, the activPAL was more precise and more sensitive to reductions in sitting time than the Actigraph. Researchers recommended that studies designed to assess sedentary behavior should consider using the activPAL.

Another objective measure is the GENEA (Gravity Estimator of Normal Everyday Activity), also known as the GeneActiv, is a wrist worn accelerometer that measures steps, activity classification and sleep. Esliger and colleagues (37) were the first to assess the technical reliability and validity of the GENEA, now called GeneActiv, using a Multi-Axis Shaking Table (MAST) as a criterion method, which mimics spatial motions in three dimensions. Sixty adult participants wore three GENEA accelerometers, one on each wrist and one positioned over the right hip, in addition to the other two accelerometers, also placed over the right hip adjacent to the GENEA. While wearing the 5 accelerometers, participants were asked to complete 10-12 semi-structured activities, such as lying, seated work, treadmill walking and free-living walking. In addition to comparing the GENEA to the Actigraph GT1M and RT3, investigators aimed to develop thresholds for sedentary, light, moderate, and vigorous intensity physical activity. Researchers found the GENEA accelerometers to have good intra-instrument and inter-instrument reliability, 1.8% and 2.4% respectively. They also showed excellent validity (r=0.97). The GENEA demonstrated excellent technical reliability (CVintra=1.4% CVinter=2.1%) and validity (r=0.98; p<0.001) using the mechanical shaker. The GENEA demonstrated excellent criterion validity using VO2 as the criterion (left wrist r=0.86; right wrist r=0.83; waist r=0.87). The GENEA demonstrated excellent concurrent validity compared to the Actigraph (r=0.92) and the RT3 (r=0.97). The waist-worn GENEA had the greatest classification accuracy (Area Under the ROC curve;

AUC=0.95), followed by the left (0.93) then right wrist (0.90). The accuracy of the waist-worn GENEA was virtually identical to the Actigraph (AUC=0.94) and RT3 (0.95). Limitations of the study include validating the vertical axis with the MAST, and not comparing the GENEA to the more widely used triaxial ActiGraph GT3x+. Researchers concluded that the GENEA is a reliable and valid measurement device capable of classifying the intensity of physical activity in adults.

Subsequently, Zhang et al. (136) also sought to classify physical activity using the raw data from the GENEA device and compare the accuracy from a wrist-worn vs. a waist-worn position. Sixty participants wore three GENEA accelerometers at the right wrist, left wrist and the waist in laboratory and free-living settings. A machine learning algorithm was used to classify data into four types of activities: sedentary, household, walking and running activities. The results demonstrated high accuracy for the waist worn (0.99), right wrist worn (0.97) and left wrist worn (0.96) GENEAs. The researchers were optimistic that GENEAs worn at the wrist had a greater potential for compliance than other devices, and all three locations demonstrated a high accuracy for physical activity classification. Phillips and colleagues (100) validated the GENEA accelerometer in children and adolescents, and create PA intensity cut points specifically for children. Researchers recruited 44 children and adolescents aged 8-14 to wear the GENEA accelerometers at multiple wear locations (both wrists and right hip), along with the ActiGraph GT1M at the hip, and a gas analyzer while completing 7 activities of daily living, such as lying, watching a DVD, playing active computer games and walking and running at various speeds. The GENEA accelerometers showed good criterion and concurrent validity at each wrist, however, the validity was excellent at the waist, and showed similar values to that of the ActiGraph GT1M. Similar to Eslinger et al. (37) researchers used ROC curve analysis to determine activity intensity cut points. A major difference from Eslinger's study was the MET cutoff values; this study used the standard MET cutoff values (3 METs for moderate-intensity, 6 METs for vigorous-intensity, whereas Eslinger used 4 METs and 7 METs for moderate- and vigorous-intensity activity, respectively. For physical activity studies in children, the GENEA accelerometer successfully classified sedentary activities and was shown to be a valid instrument.

In the most recent validation study, Welch et al. (133) sought to cross validate the GENEA wrist cut points developed by Esliger et al. (37). The study entailed 130 adults who wore a GENEA on their left wrist while performing 14 daily activities, i.e. clerical work, treadmill walking treadmill running, cycling etc. Participants also wore an oxygen mobile portable metabolic unit to measure VO2. The results of the study correctly classified GENEA intensity category for 52.9% of the observations. The accuracy for intensity classification was 69.8% for sedentary activities, 44.9% for light activities, 46.2% for moderate activities, and 77.7% for vigorous activities. Researchers suggested that the GENEA had modest intensity classification accuracy when using the cut points determined by Esliger et al. (37); most activities performed had lower than 80% accuracy. Further research is needed to determine the cut points and most effective placement of the GENEA accelerometer.

GENEA Physical Activity Classification

Esliger et al. (37) was the first study to estimate GENEA cut points to determine the time spent in sedentary, light, moderate, and vigorous intensity physical activity in adults. Physical activity was classified into: sedentary (<1.5 METS), light (1.5-3.99

METS), moderate (4.00-6.99 METS), or vigorous (7+ METS) activity. Esliger et al. (37) identified a higher intensity cut points of 4 and 7 METS for moderate intensity physical activity, rather than 3 and 6 MET thresholds. The higher intensity cut point was chosen because there was a higher likelihood that the MET threshold would be erroneous when categorizing the inactive and sedentary sample.

Using the same cut points determined by Eslinger, Zhang et al. (136) developed algorithms to for physical activity classification which categorized sedentary, household, walking and running activities. Notable activities included lying (0.94 ± 0.23 METs), standing (1.13 ± 0.25 METs), seated computer work (1.22 ± 0.29 METs), and free living activities. However, there is no evidence to date, which classifies the accuracy of GENEA devices in determining the intensity level of water based activities.

Workplace Sedentary Behavior

Sedentary behavior is most prominent in the workplace as working adults spend a significant amount of time sitting. According to the 2009 Bureau of Labor Statistics, adults spend approximately 8-9 hours of their working day sitting. Studies have demonstrated that working adults spend about one-half to one third of their workday engaging in sedentary behavior (64) and in some occupations, such as call center work can be as high as 90% (123). Office-based workers are highly sedentary making them a key target group for an intervention. As a result, the workplace is becoming a fertile environment to introduce strategies to reduce sitting time and break up periods of prolonged sitting to improve cardio metabolic health (33).

Although there have been a plethora of workplace interventions that target increasing physical activity, research examining sedentary behavior as a primary outcome is limited. In 2010, Chau et al. (26) conducted a systematic review evaluating the effectiveness with workplace interventions in reducing sedentary behaviors. Researchers concluded that there is insufficient evidence on this matter. The past research has focused on increasing physical activity was the primary outcome while reducing sitting was a secondary aim while none showed a significant decrease in the overall duration of sitting (26).

Since then, Australian researchers have examined workplace sedentary time, prolonged sedentary bouts and physical activity within three different workplace environments, offices, call centers and customer service (122). The 8 day intervention recruited 194 subjects and measured time spent sedentary, prolonged sedentary bouts (greater than 20 or 30 minutes), light intensity activity and moderate to vigorous physical activity using hip-worn accelerometers in addition to a self-report diary. Results showed that work was more sedentary and had less light intensity activity than “non-work.” Workers spend 77% of their day sedentary with half the time in prolonged bouts of more than 20 minutes. Sitting is higher on work days versus non-work day by 110 minutes per day. There was a difference between work days and non-work days, and work hours and non-work hours. Call center employee accrued more sedentary time through prolonged bouts whereas customer service employee had lowest level of sedentary time. A limitation to this study was that didn’t use activPAL to measure postural allocation.

Similarly, Parry et al. (97) conducted a study measuring sedentary behavior associated risk.50 office workers wore an Actical for 7 days and the results suggested a higher amount of sedentary time 81.8% for work hours (15.3% light activity and 2.9%

moderate to vigorous physical activity (MVPA), which was greater than non-work time 68.9%. Office workers had fewer breaks during work hours compared to non-work time.

A multi-component intervention in Australia themed "Stand Up, Sit Less, Move More" was conducted to reduce sitting time in office workers. This four week intervention comprised of organizational (workshops, emails), environmental (installation of sit-stand workstations), and individual (health coaching) approaches. Activity was measured with activPAL3, in addition to anthropometric measures (weight, waist to hip circumference), blood pressure and cardio-metabolic biomarkers (plasma glucose, triglycerides cholesterol). Additionally demographic data along with musculoskeletal disorders, work performance (absenteeism and presenteeism) was collected at baseline and post-test. The results revealed that the intervention group significantly reduced sitting time > 2 hours per 8-hour workday, with an overall reduction of 26.5% of workplace time. Workplace sitting was replaced by standing with insignificant changes to physical activity. There was no significant difference found with work performance measures. A limitation to this research was the short term efficacy in addition to the sampling of a government workplace safety group (53).

Standing in the Workplace

Ergonomic research was the first to use of height adjustable sit-stand desks in the workplace to evaluate musculoskeletal health outcomes. The literature has consistently showed that sit-stand workstation reduce musculoskeletal injuries (56; 93), improved workstation comfort rating (93, 108), reduced upper body discomfort, and reduced foot swelling (56). Only recently has sit-stand desks been introduced as a strategy to reduce sitting time in the workplace. Researchers have advocated the use of sit-stand desks to combat sedentary time and interrupt prolonged sitting in the workplace (26, 87). Furthermore, sit–stand desks are innovatively making their way into the workplace and now is accepted as a practical and acceptable means of reducing sitting time.

The Take-a-Stand Project (2011) was an endeavor led by Pronk and colleagues (104) over a 7 week period, with an intervention period of 4 weeks. The objectives for the intervention was two-fold: the first was to study the effect of a sit-stand desk on sedentary time and the second was to assess the effect of reduced sedentary time on selected health-related outcomes, mood states, work performance and office behavior. The intervention group of 24 participants received a sit-stand desk during the 4 week intervention period, whereas the comparison group (n = 10) did not. Results demonstrated a reduction in time spent sitting by 66 minutes per day (a 16% reduction), reduced upper back and neck pain by 54%, and improved mood states. After the seven week period, results indicated that "87% of participants felt more comfortable, 87% felt energized, 75% felt healthier, 71% felt more focused, 66% felt more productive, 62% felt happier, and 33% felt less stressed" due to the installation of sit-stand desks. Moreover, the Take-a-Stand Project was successful at increasing non-sitting behavior by 224% based on Experience Sampling Methodology (ESM), using experience-sampling methodology (ESM),"a methodology that described real-world situations by frequent sampling of a situation or behavior" (104). The findings suggest that using a sit-stand device at work can reduce sitting time and generate other health benefits. A limitation to the study was the short intervention period, a biased sampling pool of health promotion employees and sitting, standing, and walking was measured using ESM, rather than a postural variation device.

A pilot study by Alkhajah and colleagues (6) introduced a height adjustable sit-stand desk in the workplace as a method to reduce sedentary behavior. The study was a 3 month two-arm quasi-experimental study which observed postural allocation during a 7 day observation period, blood work (lipid panel and glucose levels) in addition to anthropometric measures at baseline and post-test. When compared to the comparison group, the intervention group reduced sitting time by 137 minutes per day, and 78 minutes per day after 3 months. Sitting was almost exclusively replaced by standing with minimal changes to stepping time. Intervention group increased the number of sit-to – stand transition per sitting hour at the workplace: Sitting time was reduced and interrupted more frequently. Intervention group increased HDL but other biomarkers not significant. The self-reported qualitative outcomes were positive: workstations were easy to use, comfortable and enjoyable, and none of participant indicated that they would rather return to their original workspace set up. A limitation to this study was that participant sampling was not randomized; participants in this study were public health researchers so it was not accurately representative of typical office workers.

Similarly, an office refurbishment in Australia allowed for the installation of sit-stand desks (49). Sedentary time was measured using quantitative survey batteries Occupational Sitting and Physical Activity Questionnaire (OSPAQ), a self-reported battery which measures time spent sitting, stand and walking on a typical day within the past 7 days, and the Workforce Sitting Questionnaire (WSA) another self- reported domain specific (work, transport, leisure) sitting time questionnaire on work and non-workdays. The qualitative component of the intervention consisted of a key informant interview, where participants were interviewed regarding the acquisition process of the sit-stand desks. The group interview consisted of discussion lead by sedentary behavior researchers, in which participants were probed about the perceptions, ease, barrier and satisfaction with sit-stand desks. At baseline, the median sitting time at work was 85%, and at follow up 60% (49). The qualitative data results suggested that initiation of the use of sit-stand desks were primarily for the potential health benefits. Factors influencing the maintenance of use consist of health/physical impacts, experimentation promoting, and perceived productivity/mental impacts. The acceptance of the sit-stand desks was well-received and results in reduction of sitting time. The small sample size, 18 of the 31 staff members completed baseline questionnaire and 13 completed follow-up questionnaires was a limitation to the study. Additionally there was no report of objective measures.

In contrast, there has been one case of a sit–stand desks intervention which has resulted in mixed findings. In a two week pilot study conducted by Gilson et al. (42), eleven office workers wore a Sensewear accelerometer for two weeks. The first week was the baseline period, and the second week was the intervention period in which participants received advice about the benefits of reducing sitting, and were given the opportunity over one week to work at one of the four of sit–stand desks. During the second week, desk use was recorded using self-reported time logs. Results did not demonstrate a significant difference between sedentary, light or moderate activity within the intervention period. Subjects only worked at the sit–stand desks for an hour per day, and one worker did not use the desk at all. This study was limited by the short term measurement period, small sample size, and the armband based accelerometer.

"Stand Up Victoria," currently in progress, is a cluster randomized controlled trial, seeking to evaluate the effectiveness of a multi-component intervention featuring the installation of a workstation & coaching to reduce sitting time in the workplace. This study is one of the first to assess the relationship between sedentary time and work-related outcomes (presenteeism, absenteeism, productivity and work performance).

Standing Desks and Productivity

No studies to date have examined the association between a sit-stand desk and workplace productivity as the primary outcome. It has been inferred that reducing prolonged siting can potentially improve productivity (reduced absenteeism/presenteeism); however studies thus far, including the multi-component intervention conducted by Healy et al. stated there was no statistical significance in presenteeism or absenteeism (53). In the previously mentioned study conducted by Straker et al. (118), the results showed that standing performance was not different from sitting. Mouse performance was more affected than typing performance. Additionally, Husemann (62) conducted a study to determine whether a sit-stand desk would affect data entry efficiency with sixty male participants. The sit-stand workstation intervention group performed simulated data entry tasks 50% of the time seated and 25% of the time in a standing position. Results demonstrated a reduction in musculoskeletal complaints in the intervention group compared to the control group, without considerably affecting data entry efficiency. There were no significant differences between the groups, but a small trend toward decreased efficiency during standing was shown. Overall, alternating between sitting and standing has been shown to "reduce physical complaints, lessen fatigue, and increase energy expenditure" (119). Consequently, increasing postural variation is believed to improve work performance (119) and self-reported work productivity (56).

Low Intensity Physical Activity in the Workplace

Physical activity can be classified into two categories: exercise and Non-Exercise Activity Thermogenesis (NEAT) (79). Exercise related activity thermogenesis involves participation in purposeful physical activities with the primary objective of improving health, fitness, and/or performance (79). On the other hand, NEAT is “energy expended for everything we do that is not sleeping, eating or sports-like exercise” and activities of daily living such as sitting, standing, walking , typing and fidgeting (79). NEAT activities are an important component of total caloric expenditure and while oftentimes overlooked, these activities account for most of one’s movement. Studies have shown that eliminating such activities can deprive 1,500 to 2,400 calories a day, and ultimately contribute to excess weight and obesity. In conjunction with low levels of physical activity, inadequate levels of NEAT have been associated to obesity (79).

Besides on-site fitness centers, treadmill workstations (TMWS) have been introduced as a means to increase physical activity in the workplace. A TMWS is a combination of a height adjustable desk with a low speed treadmill. In 2007, Dr. Levine and Dr. Miller at the Mayo Clinic (80) proposed the idea of a treadmill workstation that would allow employees to alternate between sitting and walking while working in front of a computer. It was designed to increase low intensity physical activity throughout the day. One of the first experiments assessed whether a TMWS could be used a potential weight reduction intervention. Results showed that obese individuals working at 1 mph while working expended 198 kcal hr in comparison to seated individuals of 72 kcal hr. Researchers suggested that obese individual can potentially lose 20 to 30 kg of their body weight per year if they replaced 2 to 4 hours of sitting time with walking while working

(80). Additionally, the use of TMWS can burn an additional 100 calories per hour over sitting at a desk (80).

John et al. (65) evaluated whether the use of a TMWS would increase physical activity influences anthropometric, body comp, cardio-metabolic variables in overweight and obese office workers. In a sample of twelve overweight/obese office workers, researchers measured postural allocation, steps per day, anthropometric variables, body composition, and cardio-metabolic variables at three time points (baseline, 3 months and 9 month). Participants wore an activPAL for 2 workdays during all waking hours prior to each lab visit. TMWS increased the amount of time spent standing and walking on workdays. Time standing and stepping increased from baseline to post-test months. No significant difference was found with in body weight or BMI; however differences were noted in waist to hip circumference. TMWS significantly lowered LDL, total cholesterol, triglycerides, glycosylated hemoglobin and reduced resting heart rate. The findings proved that sedentary office workers can increase light intensity physical activity and reduce sedentary time with the TMWS. TMWS promotes an increase in light intensity activity during regular office hours. Limitations to this study consisted of a small sample size, mechanical issues with the TMWS which prevented use, and no self-reported measures of frequency and duration of TMWS usage.

The longest treadmill desk intervention to date was conducted by Koepp et al. (72) for employees at Educational Credit Management Corporation. Researchers conducted a one year prospective trial to evaluate the effect of treadmill desks. Thirty six employees had their desks replaced with treadmill desks. Daily physical activity was monitored during waking hours throughout the year with an Actical. Work performance surveys were administered weekly. Body composition (air-displacement plethysmography), blood variables (lipid panel, thyroid stimulating hormone (TSH), hemoglobin A1C), blood pressure and energy expenditure were assessed at baseline, 6 months and 12 months. The results showed an increased daily physical activity with the treadmill desk intervention and a decreased daily sedentary time. Weight loss occurred with the treadmill desk intervention. Consistent with previous studies, there was a reduction in waist circumference and improvement in HDL over the 1 year intervention, however there was no changes observed in total cholesterol, LDL triglycerides, glucose, TSH and total cholesterol, and energy expenditure. In cohort with previous studies, this finding suggested the treadmill desks can improve the health of office workers without impairing their work performance.

In a recently published study, Gorman et al. (47) investigated the effect of an “activity permissible” building on workplace activity (sitting, standing, stepping), health outcomes (body composition and cardio metabolic) and work related outcomes (job satisfaction and performance) pre and post building relocation. The new building featured an environment that was activity permissive, i.e. visible staircase, height adjustable workstations, standing-option meeting rooms and common rooms, and a layout which promoted physical activity. The results of twenty seven employees indicated that the transition to the “activity permissive” workplace resulted in a significant reduction in sitting time, which increased standing time. There were no significant changes with stepping time, or health related outcomes. Participants did note an increase in self-related productivity post-move. The research did not provide an educational component, rather it was a naturalistic environmental change for staff and faculty at a physical activity research center.

Treadmill Workstations (TMWS) and Productivity

Emerging evidence is demonstrating the health improvements associated with the use of treadmills desks. Several studies are now examining the effects of treadmill desks on work performance. One of the first studies evaluating workplace productivity while using a treadmill desk was conducted by Thompson and Levine (121). The sample consisted of 11 female medical transcriptionists recruited from the Mayo Clinic. Prior to the experiment, the subjects were provided with 4 hours of training in the use of the desk, they were then assigned to transcribe tapes for 8 hour both sitting and while using the treadmill desk. Activity monitors, Actical, were worn during both sitting and walking conditions. The results revealed that the accuracy of transcription did not differ between sitting and walking transcriptions, however the speed of transcription was 16% slower while walking than while sitting. Walking resulted in an additional 100 calories expended than sitting. Researchers suggested that if transcriptionists spent 2.5 hours per day while using the treadmill desk, they would potentially lose 25 pounds per year given that their caloric intake remained stable.

In the previously mentioned study by Koepp et al. (72), results found that treadmill desks can improve the health of office workers without impairing their work performance. Treadmill desks were not associated with work performance impairments. There were no significant changes in employee workplace performance, or supervisor assessed work performance. Initially there was a suggested loss in work performance for the first 3-5 months on workplace performance, however at the end of 1 year intervention, workplace performance exceeded baseline.

Sleep

Sleep is a period of intense physiological activity necessary for brain functioning (59). Sleep needs vary from person to person. The recommended amount of sleep for most adults is at least 7-8 hours of sleep each night (129). Sleep quantity refers to the amount of time an individual spends in a sleeping state, whereas sleep quality refers to difficulty of falling asleep, staying asleep, and waking up earlier than desired (9). Sleep quality and quantity can affect critical functions of the endocrinal, metabolic and neurological systems (128).

Sleep is an important determinant for good health and overall well-being. Sleep problems have been associated with poor self-rated health, depression and anxiety, chronic medical conditions and all-cause mortality (88). According to the National Institute of Health (129), a lack of quantity or poor quality of sleep increases the risk of high blood pressure, heart disease, and other medical conditions. Furthermore, studies have also found that individuals who lack sleep are more likely to be overweight or obese, develop diabetes, and eat unhealthier (129). Sleep problems have a profound negative impact not only for the individual but also for the workplace.

The Association between Sleep, Sedentary Time, and Physical Activity

The relationship between sedentary behavior, physical activity and sleep outcomes is a subject of recent research. An emerging body of evidence has shown that sedentary behavior and sleep are independent obesity risk factors (91), however sleep impairments have been shown to increase overweight and obesity in adults and children

(91). Although sedentary behavior and sleep are both 'low energy-expending' activities; they are distinct from each other as the energy requirement for sleep is lower than any other activity (91, 2, 110). Population based studies exploring the relationship between sleep outcomes and physical activity in children and elderly populations has been widely researched; however the findings are inconsistent and contradictory. A study conducted by Foti et al. (39) investigated the association between sleep, physical activity and sedentary behaviors among high school students. These findings proved that students who engaged in daily physical activity were more likely to obtain sufficient sleep, than those who did not engage in at least 60 minutes. However, students who were sedentary using computers or playing video games for more than 2 hours/day were less likely to get sufficient sleep. In the elderly population, Guimaraes et al. (31) investigated the relationship between physically active elderly women, sedentary women and sleep. The physically active group engaged in at least 60 minutes of activity four times per week, whereas the sedentary group did not have any health restrictions however did not perform any physical activity for at least one year. Sleep was recorded on a sleep log and a ten point sleep quality visual analogue scale (VAS). The results showed that physically active elderly women had a longer total sleep time, less frequent wakefulness, and higher VAS scores. The physically active group reported better sleep quality than the sedentary group.

On the other hand, a study among U.S adolescents demonstrated that a "1-minute increase in moderate-to-vigorous physical activity was associated with a 44 percent greater odds of having no difficulty remembering when sleepy or tired" (84). Physical activity was not associated with the other sleep variables. Unlike Foti's research, physical activity was objectively measured as participants wore an ActiGraph 7164 accelerometer for 7 days. Similarly, an investigation by Ortega et al. (94) suggested that sleep duration was negatively correlated with sedentary time and positively correlated with physical activity indicators. Participants who slept longer than 10 hours spent more time on physical activities and less time on sedentary activities than those sleeping shorter durations. The findings did not suggest a link between sleep durations and physical activity.

The association between sedentary behavior and sleep is still a relatively new topic among adults, to our knowledge this relationship has yet to be examined in the working adult population with sedentary job descriptions. In Sweden, a study examined the relationship between sleep disturbances and work related factors in a healthy employed population. Work was one of the variables analyzed: sedentary work or non-sedentary work. The findings suggested that sedentary work was not related to sleep disturbances; however, there was significance between physically active work and sleep (3). Similarly, a study by Basner et al. (11) sought to identify the relationships between sleep duration and all other waking activity categories with adults using the American Time Use Survey database. The data suggested that leisure time sedentary activities were negatively associated to sleep time. Longer sleepers engaged in more television time than average sleepers. The evidence suggested that time spent working was significantly associated to sleep time. Shorter sleep time was associated longer travel time and short (<5.5 h) and prolonged sleep (≥ 8.5 h) was associated with television time. In 2013, Di Milia et al. (32) sought to examine the relationship between sleep and obesity in a sample of 11162 Australian adults using a telephone survey. After adjusting for 17 confounding variables, one of which was sitting time, the results demonstrated that work hours were negatively correlated to sleep duration, however positively associated with increased sitting time. There was no significant with physical activity and sleep.

Sleep and Cognition in the Workplace

Sleep is vital to cognitive performance and productivity (75). Insufficient sleep can have detrimental effects on cognition, including “alertness and vigilance, sensory perception, emotion, learning and memory, and executive function” (70). Consequently, sensory-perceptual processes, particularly visual processing is impaired, simple reaction time is delayed, and attention span and memory is affected (70). The hippocampal-neocortical dialogue illustrates that during sleep memories are replayed by the hippocampus, in which information is transferred between the neocortex and hippocampus, and then repeated at each sleep cycle; this biological mechanism consolidates memory traces. The effect of sleep on cognition is difficult to assess in the workplace, but it has been evaluated with medical residents. Sleep deprived interns on a traditional schedule (control) made 36% more serious medical errors than interns in the intervention group (76), and had more than twice the rate of attentional failures (82). In addition, sleep deprivation has been shown to decrease self-control, which increases hostility and resulting in increased workplace deviance (28). To our knowledge, the relationship between sleep outcomes and cognition has not been directly assessed in an office-based population.

Sleep and Productivity

Sleep is crucial component in daily functioning, particularly in the workplace, as poor sleep can affect cognition. Evidence has shown that inadequate sleep can cause poor judgment in which bad decisions are made and risks taken, all of which can consequently affect work performance (129). One of earlier studies, evaluating job performance in the Navy confirmed a positive correlation between self-perceived quality of sleep in job promotion in the military (66).

Kuppermann et al. (88) evaluated the prevalence of sleep problems in the working population and the association between mental and physical health problems, work satisfaction, job performance and absenteeism. Sampling was taken from a telecommunications company and participants received a voicemail survey. Results demonstrated the relationship between sleep problems and health problems such as headaches, neck and back pain, muscle pain and gastrointestinal problems. Individuals who had sleep problems reported poorer health, less energy, and diminished cognitive functioning. The same individuals reported lower levels of work satisfaction and had lower job performance scores, and were more likely to have medical related absence.

Furthermore, Swanson et al. (120) investigated the impact of sleep on work performance using results from 2008 National Sleep Foundation Sleep in America poll. Results showed that thirty-seven percent of participants were classified as at-risk for any sleep disorder, and these individuals had negative work outcomes when compared to those not at-risk. Additionally, presenteeism was a significant issue for individuals with at-risk individuals than not at-risk. Evidence suggests a causal relationship where long work hours may contribute to chronic sleep loss, which may in turn result in work impairment. This study suggests that the risk for sleep disorders increases the likelihood of negative work outcomes, including occupational accidents, absenteeism and presenteeism.

A study in Korea (96), examined sleep among 653 individuals in a working population. Using the Pittsburgh Sleep Quality Index (PSQI), the Epworth Sleepiness Scale (ESS), and the HPQ, investigators evaluated sleep quality and duration, sleep problems, day time sleepiness and lost productivity time. Results indicated the average sleep duration was 6 hours 37 min. The estimated cost of lost productivity time was greater in poor sleepers. Moreover, workers with a shorter sleep duration had a higher annual cost due to presenteeism. Evidence suggests that sleep disturbance affects workers' performance in an organization, in addition to individual health.

In Canada (2011), researchers studied the association between sleep problems and the work injuries. Data was utilized form the Canadian Community Health Survey Cycle, based on measures of sleep duration, frequency, and quality and sleep problems. A logistic regression model was then used to investigate the correlation between sleep and work injuries. Results found that sleep issues were significantly associated with work injury in both men and female, although more prevalent for females. Previous studies confirm this finding, the hours of sleep per night is associated with work injury. Work injuries, would in turn result in absenteeism, thus reducing employee productivity. The plethora of consistent research suggests that sleep is vital to well-being in the workplace. Inadequate sleep can affect productivity, workplace injuries, absenteeism, and medical care expenditures (96).

CHAPTER 3

METHODOLOGY

Study Setting and Design

The primary aim of the study was to determine the impact of a workplace environmental intervention to promote standing on work-related outcomes (productivity, presenteeism and cognition). The secondary aim was to examine whether work-related outcomes were associated with observed changes in: i) sitting time; ii) physical activity, and iii) sleep. The design was a natural, quasi-experimental design. There was no randomization. The study setting was at a public university in Phoenix, Arizona among staff and faculty in two colleges within the health disciplines. Participants were recruited for the study via in-person informational sessions, flyers, and emails. Respondents were invited to contact research staff by phone or email and were screened for eligibility, provided contact information, and were informed about the nature of the study. When notified of eligibility, potential participants were asked to provide verbal consent to attend a fasting screening visit at the laboratory facility, and the initial study visit was scheduled. Study procedures consisted of three phases: baseline laboratory visit with a subsequent 7-day behavioral monitoring period, 4-month intervention period, and posttest laboratory visit with a subsequent 7-day behavioral monitoring period.

Intervention

The intervention “Stand & Move ASU” consisted of two environmental changes in a newly constructed workplace. As a result of major office relocation into a new building within the same worksite, university staff and faculty had the option of a personal height adjustable workstation installed in their work area, in addition to three treadmill walking workstations located in common areas of the work environment. The desk is a Series 5 Height-Adjustable Table Worksurfaces by Details, manufactured by Steelcase Inc, Grand Rapids, MI). The treadmill workstation, Walkstation by Details is also manufactured by Steelcase Inc. Of the 33 eligible in the intervention group, 22 elected for sit-stand workstations and 23 individuals were enrolled in the study. Baseline assessments for the intervention group, “Stand and Move ASU” occurred in June 2013. University staff and faculty moved into the new workspace the first week of July 2013. A letter of support from leadership was emailed to staff during the first week of relocation to encourage the use of the sit-stand desk and treadmill workstation. Additionally, study staff provided flyers, titled “We Stand for Health” and “Stand More, Sit Less, Move More” to post in the office and individual workspace. In addition to environmental changes, all staff in the group received weekly emails for four months. The intervention is based on various Social Cognitive Theory constructs related to sitting behaviors at work. The newsletter topics include: defining sedentary behavior, goal setting, overcoming common barriers, frequently asked questions related to sitting at work, importance of social support, and maintaining progress. In order to promote interaction and psychosocial behaviors, a web form, featuring a quiz and feedback section, was attached to each newsletter. The subsequent week would act as frequently asked questions (FAQs) section, which would address questions submitted by participants. Post-test assessments occurred October - November 2013 for this group.

The comparison group “Energize your Work Day” also consisted of university staff within the same colleges with no imminent plans to re-locate during the intervention period; there were no environmental changes to this workplace. Baseline assessment for the comparison group occurred in July 2013. Participants in this group, like the intervention group, also received weekly emails on the following topics related to improved office ergonomics and increased energy during the workday in a similar format. Newsletter topics included: what is ergonomics, creating a healthy workstation, mindful posture, postural stretches and exercises, lifting and carrying techniques, desk ergonomics, desk stretches and exercises, back basics, and injury prevention strategies. Post-test assessments occurred in December 2013 for the comparison groups. Of the 17 eligible in the comparison group, 10 participants were enrolled. At the initial study visit, participants underwent informed consent procedures, and were advised of study procedures.

Objective Measures

The activPAL3c (PAL Technologies Limited, Glasgow, UK) is a small device fixed to the thigh and used to measure postural allocation (sitting, standing, lying down, walking). The device is an accelerometer that senses limb position, is the approximate size and shape of a small cell phone battery (35mm×53mm× 7mm), and samples posture >1 time/second. The activPAL captures time spent in sedentary, upright, stepping activity, step count, stepping cadence and activity score (PAL Technologies). This monitor has an 8-bit analog to digital converter, a sampling frequency of 20 Hz, and a memory of 16 Mb that allows recording of data up to 10 days. This device is worn at one third the distance between the hip and the knee on the midline of the right thigh. The device provides output using specialized software provided by the manufacturer that can be downloaded to a computer in the form of weekly, daily and hourly activity. The activPAL proprietary software (activPAL™ Professional V5.9.1.1) was used to access the recorded data, and the epoch data for the entire week of recording was exported to a Microsoft Excel format file (Microsoft Corporation, Microsoft Excel 2010, One Microsoft Way, Redmond, WA, USA). The spreadsheet displays the time engaged in sitting/lying, standing and stepping for each 15 s epoch. These values were calculated for the entire 24 h day, work hours and non-work hours, and then averaged to determine the mean time spent sleeping, sitting/lying, standing and stepping. Additionally, the activPAL 3c also provides information on the total transitions from an upright to sitting/lying position and energy expenditure (METS).

The activPAL was waterproofed by inserting it into an extra-large latex finger cot, and then the device was wrapped in Opsite Flexiform (Smith & Nephew). A piece of Hypo-allergenic medical tape (Hypafix, BSN medical GmbH) was applied onto the anterior mid-line of the right thigh, one third the distance between the hip and the knee; this acted as a barrier between the skin and the activPAL. Afterwards, the activPAL was placed onto of the tape, and then sealed onto the skin using two pieces of transparent dressing, Opsite. Participants were instructed to wear the device for 7 consecutive days following the baseline laboratory visit and 7 consecutive days following the posttest laboratory visit.

The GeneActiv, formerly GENEA, is a wrist worn accelerometer (43mm x 40mm x 13mm) that captures accelerations 100 times/second. The device is waterproof, which allows participants to wear the accelerometer 24 hours per day. The near-body temperature sensor allows the GeneActiv measures steps, activity classification, and sleep. The GeneActiv has a 12 bit analog to digital converter, a sampling frequency of up to 100 Hz, and a memory of 0.5 GB that allows recording of data up to 45 days. The manufacturer provides software to extract data, convert data, and analysis data into Excel and .bin files. The epoch converters can be used to change the epoch of each parameter. Physical activity acceleration data was gathered at 40 Hz, and sleep data was set at 40 Hz. The raw data, in form of a .csv file, was processed through a SAS 9.3 for Windows (SAS Institute Inc., Cary, NC, USA) physical activity codes taken from validation activity classification cut-points from Esliger (37) and Welch (133). Sleep scoring was summarized using the Sadeh algorithm and extracted to measures of total sleep time, sleep onset latency, wakefulness after sleep onset, and sleep efficiency.

The GeneActiv was worn like a watch on the non-dominant wrist. Participants were instructed to wear the device for 7 consecutive days following the baseline laboratory visit and 7 consecutive days following the posttest laboratory visit, throughout the entire 24 hour period including sleep time, showering, bathing or any other water activities. A self-reported a daily log was provided to document work hours, wake and sleep time, device removal for period greater than 20 minutes, and acted as a sleep diary.

Subjective Measures

Subsequent to each assessment period, productivity and presenteeism measurements were obtained using validated questionnaires administered by Qualtrics (a secure and privacy-protected computer-based survey administer). The Work Productivity and Activity Impairment General Health (WPAI:GH) is a six question instrument to assess the relationship between health conditions and productivity at work with a recall frame of 7 days. The WPAI:GH is a six question, self-reported measure with a recall time frame of 7 days. The questionnaire asks questions related to employment status; then proceeds to evaluate work time missed as a result of health problem, the number of hours and minutes missed because of other reasons (e.g., vacation, holidays) and the number of hours and minutes actually worked. The last two question ask about how much health problems affect productivity while working; and how much health problems affect regular daily activities, using a 10 point scale from 0 (no effect on work) to 10 (health problems prevented the person from working). To date, the WPAI:GH has not been validated against other measures of productivity, but has been assessed for construct validity and reproducibility (106). Test-retest reliability for all items was > 0.69 (Pearson's correlation coefficient). A regression model predicted the construct validity between 54 and 65% of the variance in WPAI:GH measures (76). WPAI:GH is scored into four sub-scores: (i) percent work time missed due to health; (ii) percent impairment while working due to health; (iii) percent overall work impairment due to health and (iv) percent activity impairment due to health. The scores are expressed as impairment percentages with higher numbers indicating greater impairment and less productivity.

The World Health Organization Health and Work Performance Questionnaire (HPQ) is a self-report instrument designed to measure employee productivity from an employer perspective. The three outcomes measured are: absenteeism, job performance, and work-related injuries and accidents. The instrument was found to have "good concordance between the HPQ and the archival data" with Pearson's correlation of 0.61 to 0.81 when measuring absenteeism and 0.89 when measuring presenteeism for a 7-day recall (69). Using a 7-day estimate, absolute absenteeism was quantified by subtracting the number of hours expected to work in a typical week from the number of hours worked in the week for the past 4 week period. Relative absenteeism was expressed as a percentage of expected hours, by dividing the absolute absenteeism value by the expected hours of work. The score ranged between a negative number represented more hours worked than expected and 1.0 (always absent). Absolute presenteeism was quantified by 10-point scale which indicated the percent of performance. A lower bound of 0, meant a lack of performance during time on the job, and an upper bound of 100 signified no lack of presenteeism on the job. Relative presenteeism was quantified as the ratio of performance to the performance of other workers at the same job. The value ranged from 0.25 to 2.00, where 0.25 is the worst performance and 2.0 is the best performance. A combined value of absenteeism and presenteeism is calculated into one work performance score. Higher scores indicate improved productivity. The relative variables (absenteeism and presenteeism) were interpreted for this study, because the effects of health problems on work absence vary with full time employees vs. part time employees, and the values are best conceptualized as a proportional rather than absolute.

The Endicott Work Productivity Scale (EWPS) is a 25-item questionnaire designed to quantify the frequency of work performance and productivity attitudes and behaviors over a range of medical conditions. The instrument covers four domains: attendance, quality of work, performance capacity, and personal factors to include, social, mental, physical, and emotional. The reliability and validity of EWPS has only been tested in patients with depression. Additionally the results demonstrated good test-retest reliability with an intra-class correlation coefficient for the total EWPS score was 0.9. Internal consistency was found to be 0.93 in the psychiatric sample and 0.92 in the community sample (Cronbach's α). The content and criterion validity of the EWPS have not been assessed. The scoring method is the sum of 25 items is scored based on a 5 point-scale. The total score ranges from 0 (best score) to 100 (worst score).

The Stanford Presenteeism Scale (SPS-6) assesses the relationship between presenteeism, health issues, and productivity in the workplace. The six question instrument uses a Likert 5-item response scale based on a 1-month recall period to scale assess the ability to accomplish tasks and focus despite health impairment. The sum of the six items represents an overall presenteeism score (with a higher score indicating more presenteeism). The SPS-6 overall presenteeism score demonstrated high internal consistency with a Cronbach's α of 0.80. The scoring method is the sum of 6 items. The total score ranges from 6-30, with lower scores indicating lower presenteeism.

Cognitive Measures

Cogstate (Cogstate Ltd, Melbourne, Australia), is a computerized test battery used to identity and measure cognitive impairment. The battery of tests is customizable so that researchers can test a specific area of cognition. The Cogstate battery was shown to adequately define cognitive psychological paradigms among a mentally impaired population and was found to have acceptable construct ($r = 0.49$ to 0.83) and criterion validity (Cohen's d's = 2.60 to 21.80) (27). Study participants completed tests similar to the Early Phase Battery which included the following tasks: Groton Maze Learning Test (executive function and spatial problem solving), card identification (choice reaction time), and card detection (simple reaction time/psychomotor function). At the beginning of each task, written instructions were presented on the screen to indicate the task rules. Each participant was given an interactive demonstration and completed practice trials before the task officially began. The cognitive tests can be completed in 12 -17 minutes (29).

The Groton Maze Learning test is a maze that requires a 28- step pathway shown on a grid of 10 x 10 tiles. This test battery measures executive functioning by calculating the total numbers of errors for 5 consecutive trials. A lower score translates to better performance. The remaining two tasks are in the form of card games. The card identification task requires the subject to identify whether the card is red using the keyboard or computer mouse. Identification task measures reaction time through the speed of performance in Log10 milliseconds. A lower score is indicative of increased reaction time. The card detection test entails the subjects to respond as quickly and accurately as possible using the keyboard or computer mouse. Detection task measures reaction time and psychomotor function through the speed of performance in Log10 milliseconds. Similarly, a lower score translates into an increased reaction time and psychomotor function performance.

Participants completed a battery of cognitive tests via Cogstate online software which measures cognitive domains including, visual motor function, executive function/spatial problem solving, psychomotor function/speed of processing, visual attention/vigilance, visual learning & memory, verbal learning & memory, attention/working memory and social cognition. The test battery was presented on a laptop or desktop computer. Upon completing the laboratory-based measures, participants were outfitted with behavioral monitoring devices, activPAL and GeneActiv. Immediately after their laboratory visit, participants were asked to complete a battery of questionnaires administer via Qualtrics (a secure and privacy-protected computer-based survey administer), in the office.

Statistical Analyses

Statistical analysis was conducted using SPSS version 20 for windows (SPSS, Chicago, IL). Mean, standard deviation (SD) and frequencies were calculated for all variables. Statistical significance was defined as $p < 0.05$. Data was analyzed for normality ($p > 0.05$). Log transformations were used to improve the normality for all outcomes. Missing values at posttest were carried forward in line with intent-to-treat principles. An 8-hour workday standardized method was calculated to determine average sitting minutes per day. The standardized equation accounts for differences in total work time (standardized 8-hr day minutes= number of observed sitting minutes * 480), divided by the number of total work time minutes observed (50). Physical activity during the workday was also standardized into an 8-hour workday, and converted into a percentage (standardized 8-hr day percentage = number of observed minutes* 480, divided the number of wear time *100). Baseline adjusted analysis of covariance was used to determine whether outcome variables (productivity, presenteeism and cognition) varied between the intervention and comparison groups at post-test. A residual analysis in regression was conducted to determine the differences between observed changes and predicted changes in sitting time, physical activity and sleep. In order to assess the association between relationship between work-related outcomes and sitting time, physical activity in the workplace, and sleep, Pearson's correlation coefficient was calculated for continuous change variables (derived from residual method). The alpha level of significance was defined as 0.05. Magnitude of effect sizes were categorized as small (eta squared <0.01), medium (eta squared = 0.06), and large (eta squared = 0.12).

CHAPTER 4

DATA ANALYSIS AND RESULTS

Table 1 provides an outline of the demographic information for the study sample. The age of the sample ranged from 25 to 63 years. The comparison group participants were slightly younger than intervention group participants. Participants had a blood pressure within the normal range, and the mean body mass index (BMI) was in the overweight category. Participants were predominately female, white, and had completed a 4-year college degree. The job classification for participants was primarily composed of "managerial and professional" individuals. All participants reported good to excellent health. The only significant difference between groups was educational background, where nine of the ten participants in the comparison group completed a Master's Degree.

E-newsletter usage

E-newsletter usage was monitored throughout the intervention via an interactive a web form, featuring a quiz and feedback section, which was attached to each newsletter. Analysis revealed that both groups read less than half of the prescribed e-newsletters, and there were no differences between groups. Also, there was no relationship between e-newsletter usage and changes in sitting time (Table 2).

Aim 1: Productivity

Tables 2, 3 and 4 presents the productivity measures. The results from EWPS (Table 2) showed that work performance slightly increased for the intervention by 1.99%. No changes were observed for the comparison group and there was no significant difference between groups.   The effect size for this analysis was small.

The WPAI:GH analysis demonstrated an increase in the four sub- categories: percent work time missed due to health, percent impairment while working due to health, percent overall work impairment due to health and prevent activity impairment due to health (Table 3). This increment translates into greater work impairment and less productivity. After adjusting for baseline values, participants stated that they were more affected by their health problems after the 16 week intervention. The intervention group reported a prominent increase in the percent of time work time missed due to health by five-fold, in addition to a 34.34% increase in work impairment due to health. A detriment in work impairment was evident for both groups, but there was no statistical significance between groups, with a small to medium effect size.

The results from HPQ (Table 4) measured both absenteeism and presenteeism based on a 7-day recall period. There was no significant difference between groups for absenteeism values, with a small effect size. The negative absenteeism scores for the intervention group indicate more hours were worked than expected. The presenteeism score indicates that the intervention group improved their by 5%, whereas there were no changes observed with the comparison group. A combined score of absenteeism and presenteeism showed that both groups collectively improved their work performance. The HPQ did not demonstrate any difference between groups for all sub-measures.

Aim 1: Presenteeism

Presenteeism was assessed using questions about presenteeism that were extracted from Stanford Presenteeism Scale 6 (SPS-6) and HPQ. When examining presenteeism measures with the HPQ (Table 4), the intervention group improved their presenteeism scores. This change can be interpreted as an increased performance during time on the job. There was no significant found between the groups.

The SPS-6 battery (Table 5) which specifically measures presenteeism found a reduction in presenteeism scores for both groups. The intervention group had lowered presenteeism scores by 3.11, which meant that participants improved their overall work performance. However there was no significant difference between groups, with an effect size of (eta squared = 0.03).

Aim 1: Cognition

Table 6 presents the cognition performance measures. For the Detection Task and Identification task, the speed of performance increased both groups, which meant that their reaction time declined over time and their scores did not improve from pretest values. The Groton Maze Learning Test did however demonstrate an improvement with executive functioning with a decrease in errors made. The intervention group collectively reduced by 3.52 errors, and the comparison group reduced 4.50 errors. There was no significant difference between groups for posttest values and a small effect size.

Aim 2: Sitting time during the workday

Pretest inclinometer monitoring found that the intervention group decreased their sitting time (Table 7). At baseline, the intervention group spent 70.28% of their workday in sitting, however by the end the intervention, their sitting time decreased by 9.34% to 63.71% of sitting time during the workday. Although the comparison group did not reduce their sitting time, there was no significant difference between groups in the amount of change. The effect size for this analysis was small (eta squared = 0.07).

Aim 2: Pattern of sedentary time, light intensity, moderate and vigorous physical activity

Table 8 presents the percent of physical activity during the workday. The results demonstrate that both groups spent a large percentage of their day sedentary, 86.55% and 85.21% intervention and comparison groups, respectively. In spite of a small percent decrease in sedentary time observed by the comparison group, this change was not significant between groups. The comparison group increased their light intensity physical activity by 9.73%, however the differences were not significant between groups and had a small effect size. Vigorous intensity physical activity was not significant between groups.

Aim 2: Sleep Patterns

Sleep patterns did not improve on all accounts for both groups (Table 9). The minutes of total sleep time and percent of sleep efficiency decreased, while minutes of sleep onset latency and wakefulness after sleep onset increased. Both groups had modest, non-significant decreases in total sleep time. Sleep onset latency did not change for the comparison group, however increased for the intervention group. Minutes of wakefulness after sleep onset modestly increased in both groups. Sleep efficiency declined for both groups.

Aim 2: Relationship between work-related outcomes and sitting time.

The observed correlated changes between work-related outcomes and sitting time is presented in Table 10. EWPS scores demonstrated a non-significant correlation between productivity improvements and decreased sitting time. SPS-6 scores indicated no relationship between presenteeism changes and sitting time changes. WPAI:GH scores indicated improvements in all subscales were correlated with decreases in sitting time, although these were not significant**.** A non-significant correlation is observed which suggests that increased sitting time could potentially impair activity. HPQ scores demonstrated decreases in absenteeism and presenteeism were associated with decreased sitting time, although these relationships were not significant. Finally, cognitive performance improvements were associated with increases in sitting time, although these relationships were also not significant.

Aim 2: Relationship between work-related outcomes and physical activity

The relationship between workday physical activity and work-related outcomes is presented in Table 11. EWPS scores revealed that improved productivity is associated with decreased sitting time while productivity declines with decreased physical activity; this observation is not significant. SPS-6 scores demonstrated an improvement in presenteeism was associated with decreased sitting time and MVPA. However this relationship was not significant, and was not detected with light intensity physical activity. WPAI:GH scores indicated improvements were correlated with decreased sitting time. A significant association was found between increased sedentary time with activity impairment. HPQ scores demonstrated that an increase in absenteeism and presenteeism was associated with increased sedentary time. However, a decrease in absenteeism and presenteeism was associated with increased physical activity (light and MVPA). Work performance was improved with decreased sedentary time. Cognitive performance improved with increased physical activity. However this trend was not evident for executive functioning tasks.

Aim 2: Relationship between work-related outcomes and sleep.

The observed correlated changes between work-related outcomes and sleep patterns are illustrated in Table 10. There was a significant correlation between sleep parameters and productivity measures. EWPS scores indicated a strong significant correlation was observed between increased wakefulness after sleep onset and decreased productivity. SPS-6 scores also established a significant association with improved presenteeism and increased sleep efficiency. Moderate correlations were observed between improvements in productivity and presenteeism and more healthful sleep patterns (wakefulness after sleep onset, sleep efficiency). Furthermore, work impairment findings (WPAI:GH) demonstrated a significant association between decreases in sleep onset latency and decreases in work time missed, impairment while working, and overall work impairment. A decrease in total sleep time and decrease in activity impairment due to health was found to have a significant relationship. There was no significance observed between cognitive performance and sleep patterns.

Table 1. Frequency and percentages of participant characteristics.

	Intervention	Comparison	Total
N	23	10	33
	n (%)	n (%)	n (%)
Female	17 (73.9)	10 (90.0)	27 (78.8)
Age, M ± ±SD	41.3 ± 11.8	35.4 ± 10.6	39.5 ± 11.6
18-34 years	9 (39.1)	7 (70.0)	16 (48.5)
35-49	9 (39.1)	1 (10.0)	10 (30.3)
50-65	5 (21.7)	2 (20.0)	7 (21.2)
Race			
White (%)	17 (73.9)	10 (100)	27.0 (81.8)
Black (%)	1 (4.3)	0	1 (2.9)
Hispanic or Latino (%)	3 (13.0)	0	3 (8.6)
Other (%)	2 (8.7)	0	2 (5.7)
Body Mass Index, M (SD)	25.9 ± 5.3	25.1 ± 3.8	25.7 ± 4.9
Normal	11 (47.8)	6 (60.0)	17 (51.5)
Overweight	9 (39.1)	3 (30.0)	12 (36.4)
Obese	3 (13.0)	1 (10.0)	4 (12.1)
Body Fat (%)	29.0 ± 8.1	32.5 ± 8.5	30.0 ± 8.3
Systolic BP, M (SD)	121.3 ± 20.3	124.3 ± 11.1	122.2 ± 17.9
Diastolic BP, M (SD)	77.1 ± 12.3	76.5 ± 4.6	76.9 ± 10.5
Education*			
< 4-year college	4 (17.4)	0.0	4 (11.4)
4-year college	13 (56.5)	1 (10.0)	14 (40.0)
Masters Degree	2 (8.7)	9 (90.0)	11 (33.3)
Doctoral or Professional Deg	4 (17.4)	0.0	4 (11.4)
Job Classification			
Customer service (%)	0	2 (20.0)	2 (6.1)
Clerical (%)	4 (17.4)	0	4 (12.1)
Managerial (%)	5 (21.7)	2 (20.0)	7 (21.2)
Professional Degree (%)	11 (47.8)	5 (50.0)	16 (48.5)
Other (%)	3 (13.0)	1 (10.0)	4 (12.1)
Self-rated health			
Excellent (%)	5 (21.7)	0	5 (15.2)
Very Good (%)	11 (47.8)	6 (60.0)	17 (51.5)
Good (%)	7 (30.4)	4 (40.0)	11 (33.3)

*Intervention and comparison groups statistically difference, $p<.05$.

BP = blood pressure

Table 2. Number of email newsletters read by group

Variable	Intervention	Comparison	Total
	6.17 ± 1.21	5.75 ± 1.39	6.03 ± 5.41
0 - 4 e-newsletters	10 (43.5)	5 (50.0)	15 (45.5)
5 - 8 e-newsletters	7 (30.4)	3 (30.0)	10 (30.3)
9 - 12 e-newsletters	2 (8.7)	1 (10.0)	3 (9.1)
13 or more	4 (17.4)	1 (10.0)	5 (15.2)

Table 3. Mean (SD) Endicott Work Productivity Scale (EWPS)

Variable	Intervention (n=23)	Comparison (n=10)	F	*p*	Eta squared
Endicott Work Productivity Scale (EWPS)			0	0.991	0
Pretest[a]	43.14 (10.74)	41.44 (13.09)			
Posttest[b]	42.28 (9.31)	41.00 (16.01)			

ANCOVA models were adjusted for baseline values

a. Five individuals did not have pretest values (3 intervention, 2 comparison)

b. Three individuals did not have posttest values (2 intervention, 1 comparision)

Table 4. Mean (SD) Work Productivity and Activity Impairment General Health (WPAI:GH)

Variable	Intervention (n=23)	Comparison (n=10)	F	*p*	Eta squared
Percent work time missed due to health			0.00	0.96	0.00
Pretest	0	7.50 (23.72)			
Posttest[a]	4.78 (20.08)	11.5 (23.81)			
Percent impairment while working due to health			0.65	0.43	0.02
Pretest	2.61 (12.51)	9.00 (28.46)			
Posttest[a]	18.70 (66.69)	20.0 (37.42)			
Percent overall work impairment due to health			0.00	0.97	0.00
Pretest	0	6.12 (19.34)			
Posttest[a]	4.44 (20.84)	9.85 (19.65)			
Percent activity impairment due to health			1.35	0.26	0.04
Pretest	3.48 (16.68)	7.00 (22.14)			
Posttest[a]	8.69 (20.29)	21.00 (35.10)			

ANCOVA models were adjusted for baseline values

a. Six individuals did not have posttest values (5 intervention, 1 comparison)

Table 5. Mean (SD) Health and Work Performance Questionnaire (HPQ)

Variable	Intervention (n=23)	Comparison (n=10)	F	*p*	Eta squared
Relative Absenteeism (%)			0.03	0.88	0.00
Pretest[a]	- < 1.00 (0.31)	3.00 (0.22)			
Posttest[b]	- 7.00 (0.18)	- 5.00 (0.19)			
Relative Presenteeism (%)			0.25	0.63	0.01
Pretest[a]	104 (0.19)	107 (0.24)			
Posttest[b]	109 (0.19)	107 (0.16)			
Work Performance (%)			0.01	0.87	0.00
Pretest[a]	107 (0.44)	104 (0.34)			
Posttest[b]	115 (0.25)	112 (0.30)			

ANCOVA models were adjusted for baseline values

a. Two individuals did not have pretest values (2 intervention)

b. Three individuals did not have posttest values (3 intervention)

Table 6. Mean (SD) Stanford Presenteeism Scale 6 (SPS-6)

Variable	Intervention (n=23)	Comparison (n=10)	F	*p*	Eta squared
Stanford Presenteeism Scale 6 (SPS-6)			0.79	0.38	0.03
Pretest[a]	15.21 (5.90)	15.10 (5.02)			
Posttest[b]	10.55 (8.18)	14.20 (5.27)			

ANCOVA models were adjusted for baseline values

a. Four individuals did not have pretest values (4 intervention)

b. Three individuals did not have posttest values (3 intervention)

Table 7. Mean (SD) Cognitive performance measurement battery

Variable	Intervention (n=23)	Comparison (n=10)	F	*p*	Eta squared
Detection Test†			0.62	0.44	0.02
Pretest[a]	2.49 (0.09)	2.50 (0.08)			
Posttest[b]	2.54 (0.14)	2.51 (0.07)			
Groton Maze Learning Test‡			0.20	0.66	0.01
Pretest	56.21 (17.48)	51.50 (17.26)			
Posttest	52.69 (17.96)	47.00 (19.96)			
Identification Test†			1.22	0.28	0.04
Pretest[c]	2.34 (0.93)	2.70 (0.09)			
Posttest[d]	2.69 (0.09)	2.71 (0.08)			

ANCOVA models were adjusted for baseline values

a. Two individuals did not have pretest values (2 intervention)

b. Three individuals did not have posttest values (3 intervention)

c. Eight individuals did not have pretest values (8 intervention)

d. Nine individuals did not have posttest values (7 intervention, 2 comparison)

† log10 per millisecond

‡ Total numbers of Errors made

Table 8. Mean (SD) workday sitting time over a standardized 8-hour day

Variable	Intervention (n=23)	Comparison (n=10)	F	p	Eta squared
Minutes of workday Sitting Time			2.15	0.15	0.07
Pretest[a]	337.35 (63.23)	344.98 (77.47)			
Posttest[b]	305.83 (79.16)	343.63 (87.32)			

ANCOVA models were adjusted for baseline values

a. Two individuals did not have pretest values (2 intervention)

b.Three individuals did not have postest values (2 intervention, 1 comparison)

Table 9. Percent of workday physical activity standardized over a 8-hour period

Variable	Intervention (n=23)	Comparison (n=10)	F	p	Eta squared
Percent of workday sedentary time (%)			0.61	.441	0.02
Pretest[a]	86.55	85.21			
Posttest[b]	85.90	83.64			
Percent of light intensity physical activity (%)			1.56	0.22	0.05
Pretest[a]	12.70	13.82			
Posttest[b]	12.45	15.31			
Percent of moderate to vigorous physical activity (%)			0.49	0.49	0.02
Pretest[a]	0.72	0.97			
Posttest[b]	1.18	1.06			

ANCOVA models were adjusted for baseline values

a. One individual did not have pretest values (comparison)

b.Three individuals did not have postest values (2 intervention, 1 comparison)

Table 10. Mean (SD) Objective sleep parameters

Variable	Intervention (n=23)	Comparison (n=10)	F	p	Eta squared
Minutes of Total sleep time			0.12	0.73	0.00
Pretest[a]	378.39 (55.09)	381.37 (53.08)			
Posttest[b]	372.77 (56.07)	367.78 (39.11)			
Minutes of Sleep onset latency			0.67	0.42	0.02
Pretest[a]	23.12 (12.44)	22.83 (11.66)			
Posttest[b]	28.16 (21.94)	22.55 (10.19)			
Minutes of Wakefulness After Sleep Onset			1.64	0.21	0.05
Pretest[a]	60.04 (42.56)	80.82 (56.41)			
Posttest[b]	72.81 (34.53)	100.82 (55.30)			
Sleep Efficiency %			1.53	0.23	0.05
Pretest[a]	81.64 (10.58)	79.21 (10.91)			
Posttest[b]	79.59 (7.39)	75.19 (9.94)			

ANCOVA models were adjusted for baseline values

a. Three individuals did not have pretest values (2 intervention, 1 comparison)

b. Four individuals did not have posttest values (2 intervention, 2 comparision)

Table 11. Correlated changes (Pearson) between work related outcomes and sitting time.

Variable	Pretest-posttest changes in sitting time
Endicott Work Productivity Scale (EWPS)˅	0.26
Stanford Presenteeism Scale 6 (SPS-6)˅	0.03
Work Productivity and Activity Impairment General Health (WPAI:GH)˅	
Work time missed (%)	0.04
Impairment while working (%)	0.01
Overall work impairment (%)	0.03
Activity impairment (%)	0.33
Health and Work Performance Questionaire (HPQ)	
Relative Absenteeism˅	0.20
Relative Presenteeism^	0.17
Work Performance^	-0.02
Cognitive measures˅	
Detection Test	-0.32
Groton Maze Learning Test	-0.10
Identification Test	-0.06

^ Greater values indicate improved productivity, presenteeism and cognitive performance

˅ Lower values indicate improved productivity, presenteeism and cognitive performance

Table 12. Correlated changes (Pearson) between work related outcomes and workday physical activity.

Variable	Sedentary	Light	Moderate to Vigorous
Endicott Work Productivity Scale (EWPS)˅	0.12	-0.05	-0.20
Stanford Presenteeism Scale 6 (SPS-6)˅	0.13	-0.16	0.20
Work Productivity and Activity Impairment General Health (WPAI:GH)˅			
Work time missed (%)	-0.09	0.08	0.07
Impairment while working (%)	-0.08	0.09	-0.003
Overall work impairment (%)	-0.07	0.08	0.01
Activity impairment (%)	0.36*	-0.28	-0.10
Health and Work Performance Questionaire (HPQ)			
Relative Absenteeism˅	0.05	-0.16	-0.10
Relative Presenteeism^	0.30	-0.23	-0.07
Work Performance^	0.19	-0.07	0.03
Cognitive measures˅			
Detection Test	0.18	-0.10	-0.10
Groton Maze Learning Test	-0.33	0.25	-0.22
Identification Test	0.12	-0.09	-0.14

*. Correlation is signficant at the 0.05 level (2-tailed)

^ Greater values indicate improved productivity, presenteeism and cognitive performance

˅ Lower values indicate improved productivity, presenteeism and cognitive performance

Table 13. Correlated changes (Pearson) between work related outcomes and objective sleep parameters.

Variable	SOL	WASO	SE	TST
Endicott Work Productivity Scale (EWPS)[v]	-0.24	-0.87**	0.19	0.27
Stanford Presenteeism Scale 6 (SPS-6)[v]	-0.28	-0.34	0.38*	0.22
Work Productivity and Activity Impairment General Health (WPAI:GH)[v]				
Work time missed (%)	0.59**	0.15	-0.21	0.16
Impairment while working (%)	0.47**	-0.16	0.14	0.33
Overall work impairment (%)	0.60**	0.15	-0.21	0.16
Activity impairment (%)	-0.25	-0.31	0.33	0.43*
Health and Work Performance Questionaire (HPQ)				
Relative Absenteeism[v]	-0.10	0.19	-0.16	-0.13
Relative Presenteeism^	-0.03	0.04	-0.05	0.02
Work Performance^	0.07	-0.05	0.02	0.04
Cognitive measures[v]				
Detection Test	-0.17	-0.19	0.32	0.34
Groton Maze Learning Test	0.17	0.13	-0.17	-0.13
Identification Test	-0.08	0.02	-0.04	-0.03

***. Correlation is signficant at the 0.001 level (2-tailed)

**. Correlation is signficant at the 0.01 level (2-tailed)

*. Correlation is signficant at the 0.05 level (2-tailed)

^ Greater values indicate improved productivity, presenteeism and cognitive performance

[v] Lower values indicate improved productivity, presenteeism and cognitive performance

Figure 1. Stand and Move ASU study participant flow

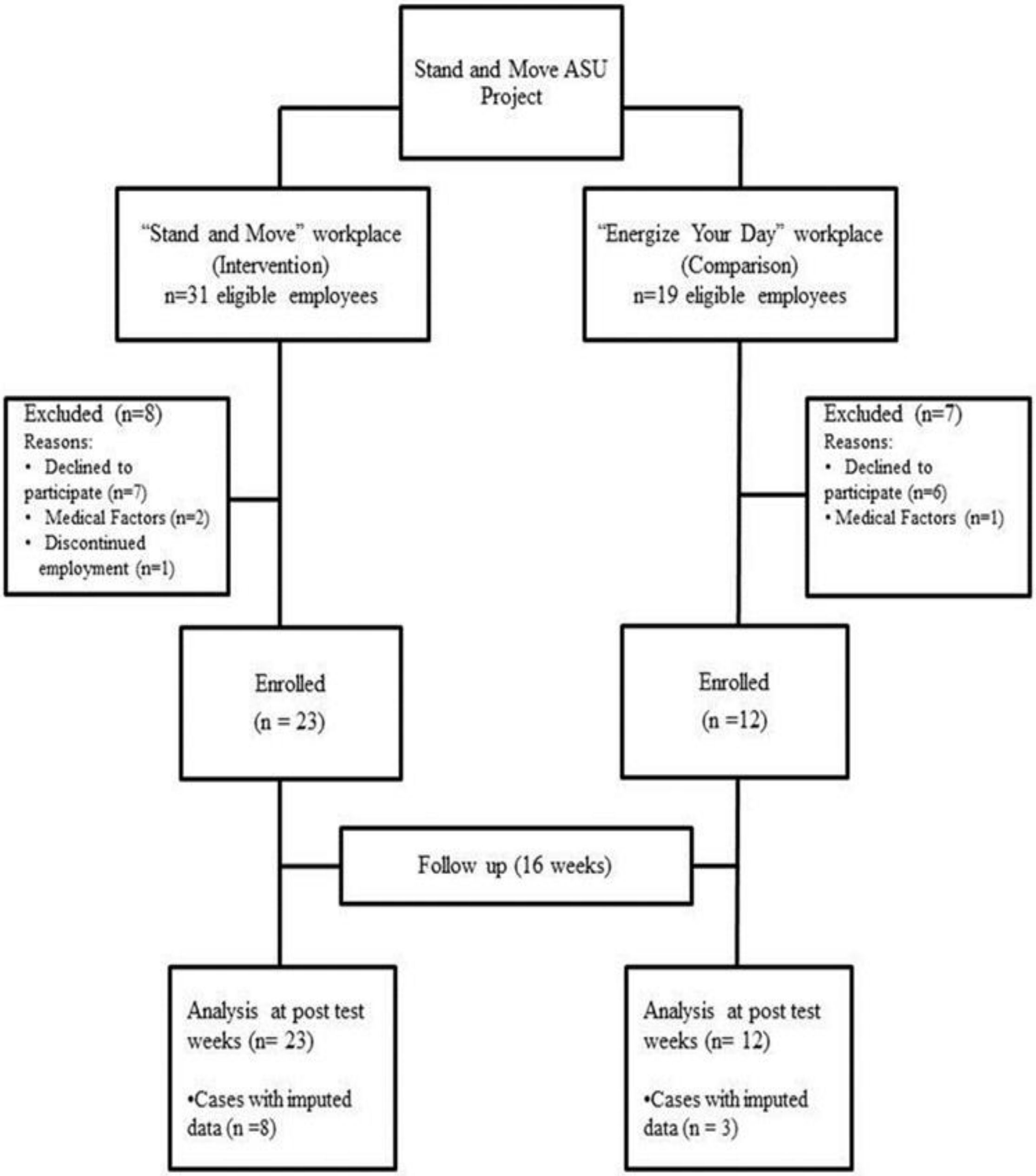


Figure 2. Mean Endicott Work Productivity Scale

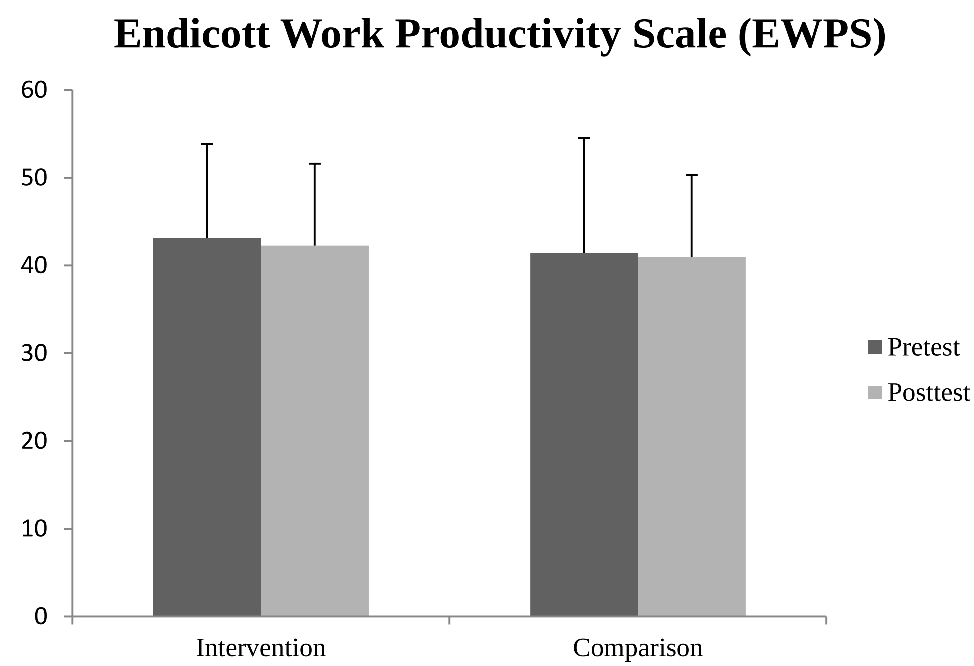
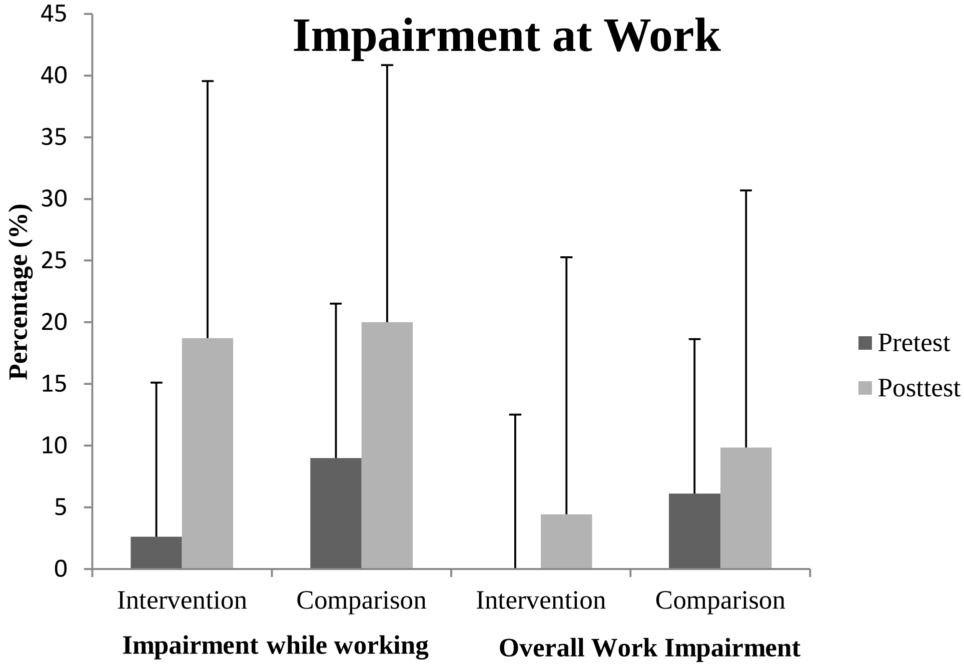


Figure 3. Work Productivity and Activity Impairment General Health (WPAI:GH)



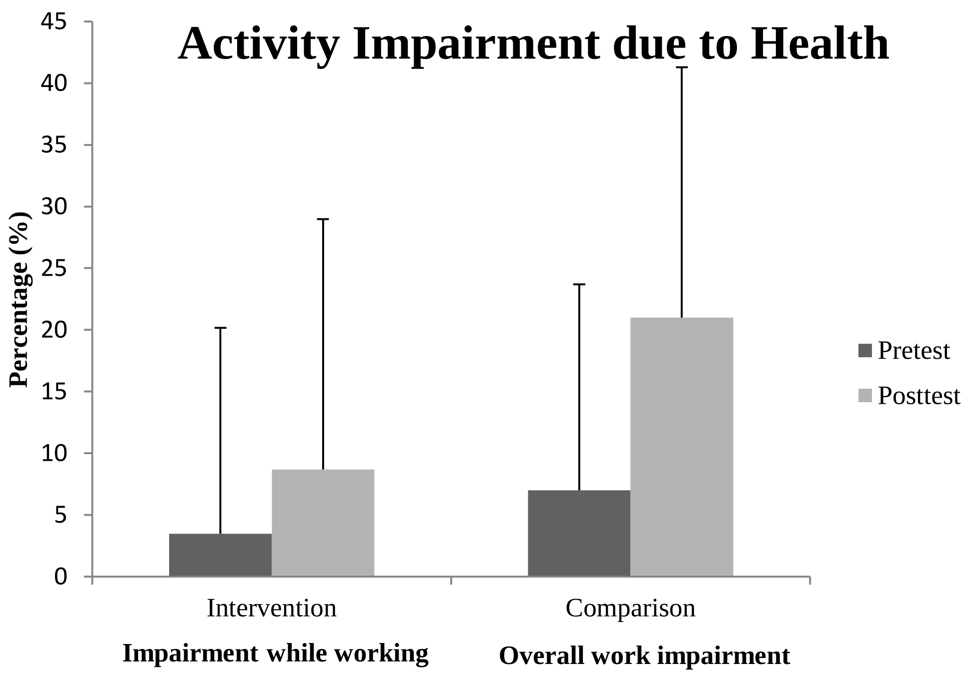
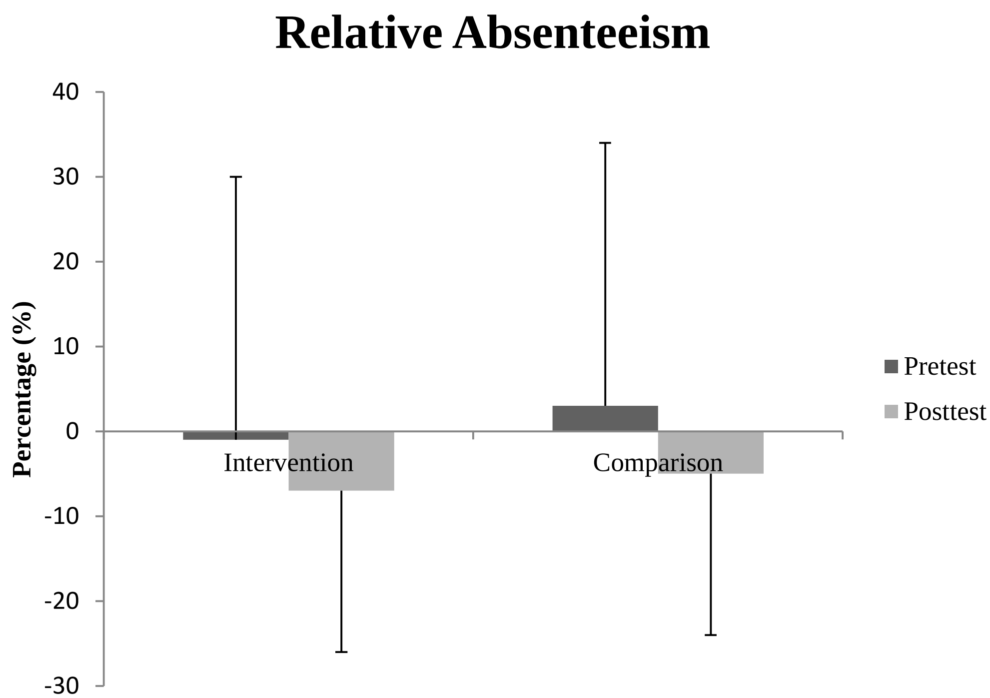
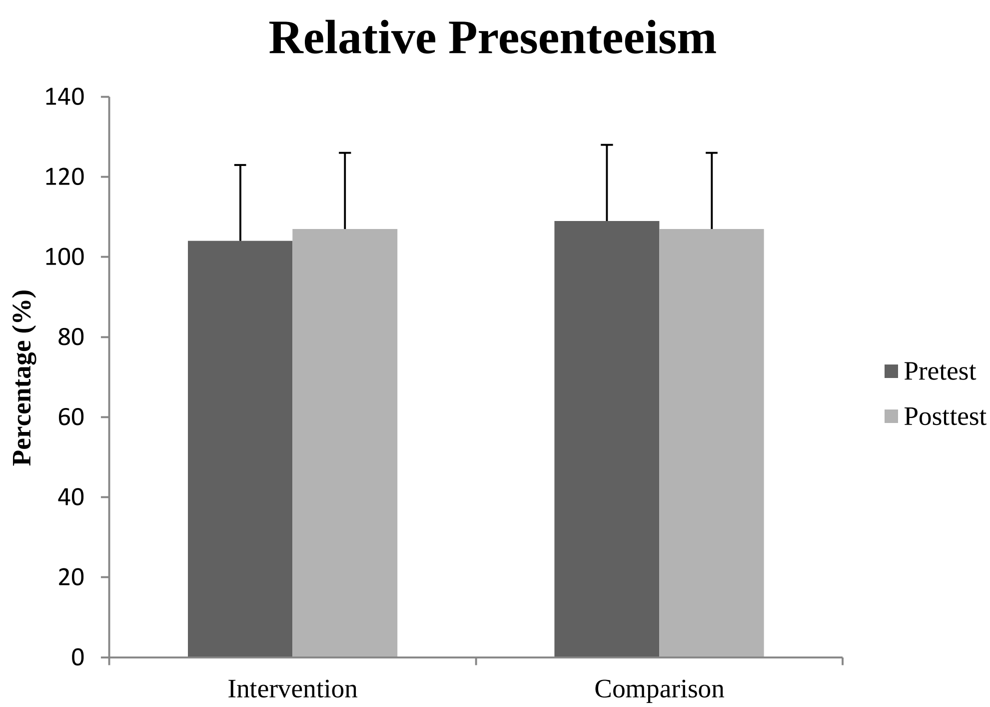


Figure 4. Health and Work Performance Questionnaire (HPQ)





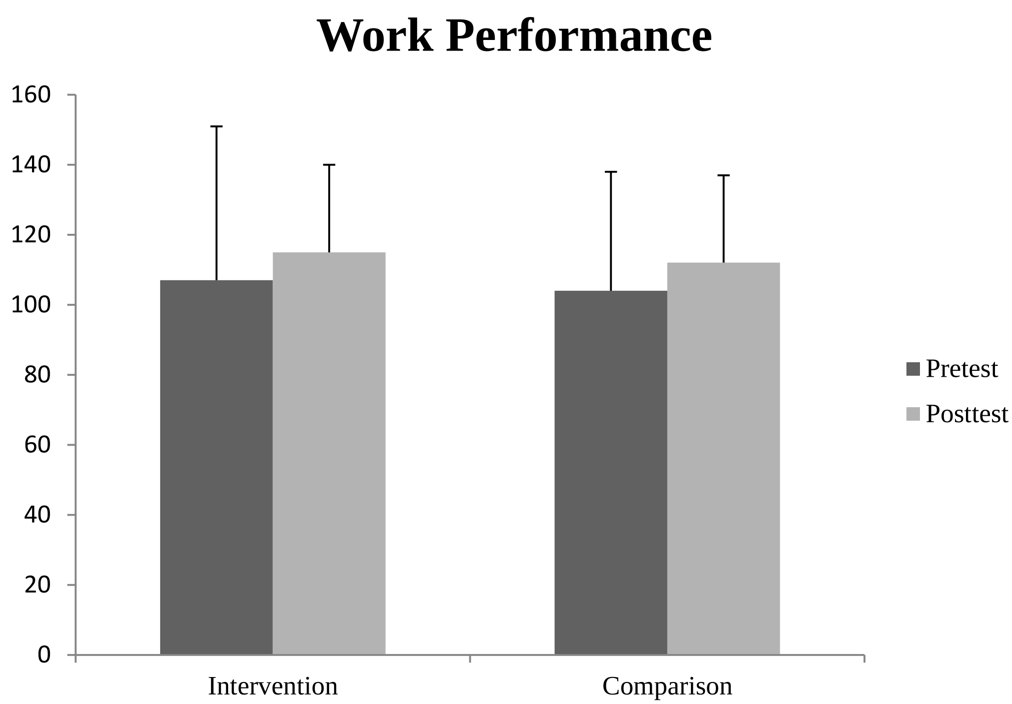

Work Performance
160
140
120
100
80
60
40
20
0
Intervention
Comparison
Pretest
Posttest

Figure 5. Stanford Presenteeism Scale 6 (SPS-6)

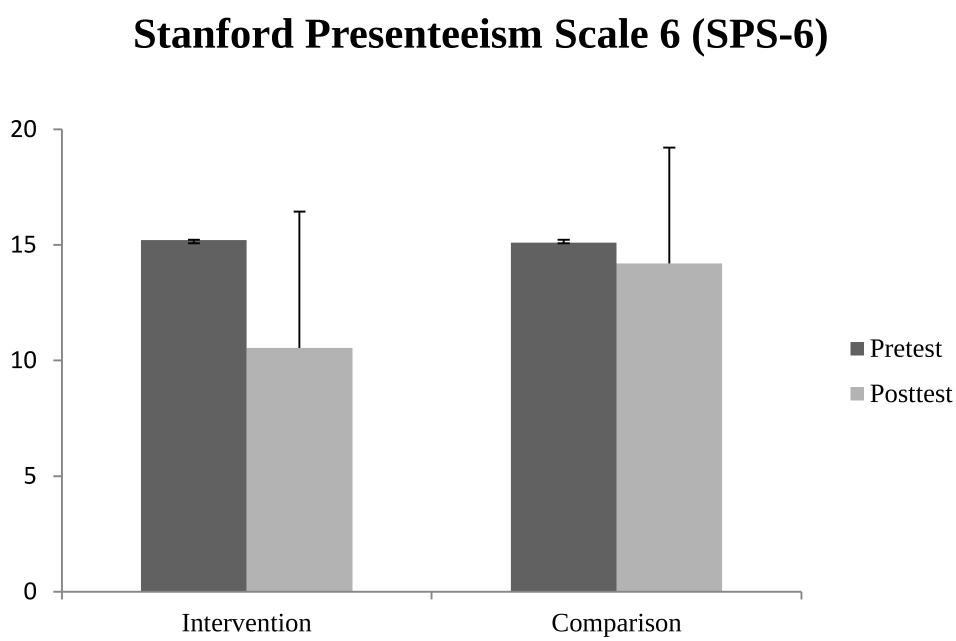
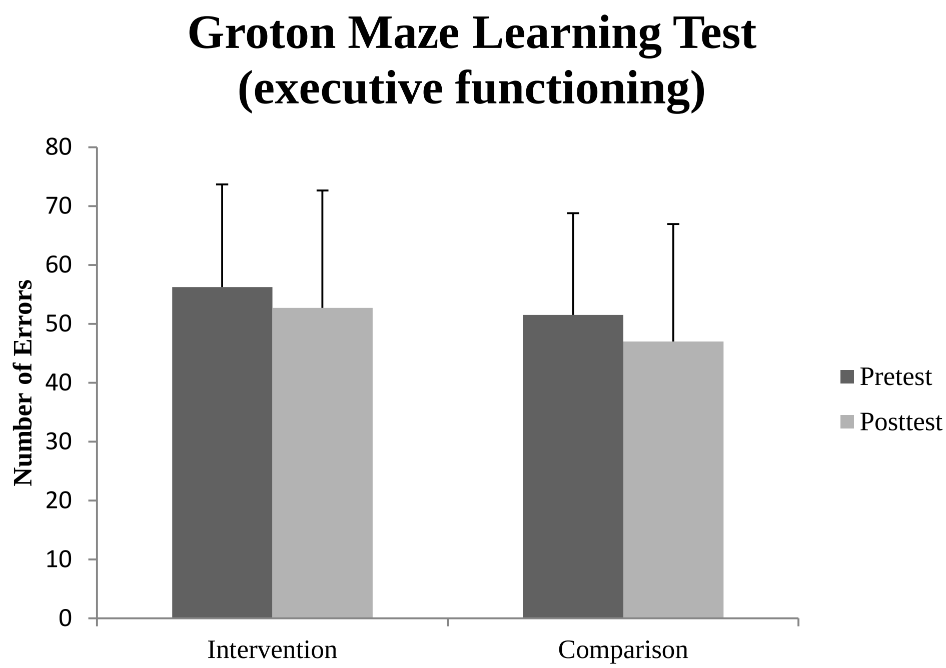
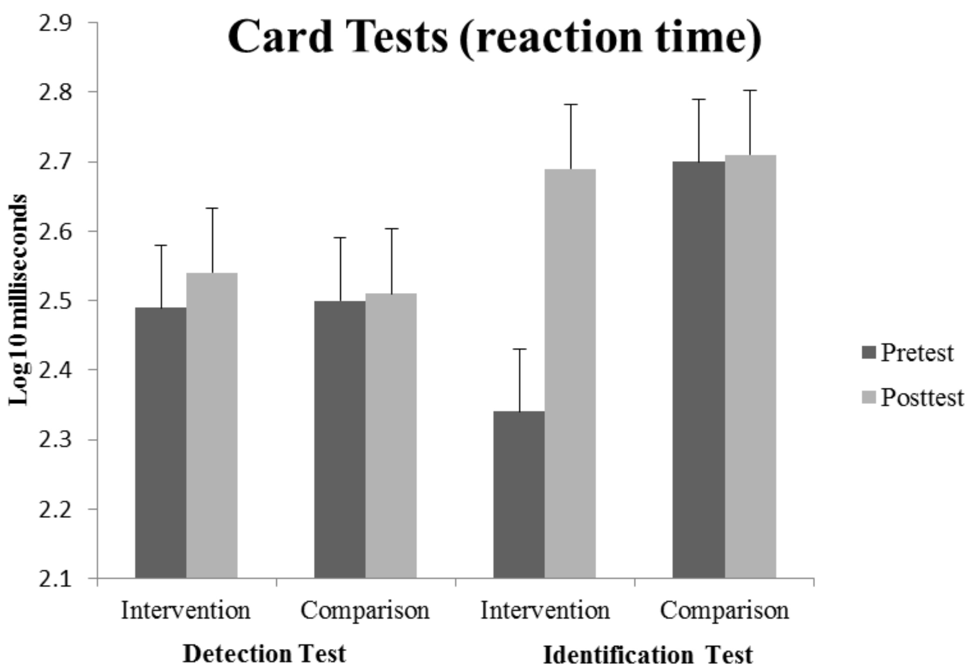


Figure 6. Cognitive performance measurement battery





CHAPTER 5

DISCUSSION

The purpose of the study was to examine the impact of a workplace environmental intervention to promote standing on work-related outcomes (productivity, presenteeism and cognition) over a 16 week period. Secondarily, this study investigated whether changes in work-related outcomes were associated with observed changes in sitting time, physical activity and sleep. Sedentary behavior has been identified as an increasingly deleterious risk factor in workplace health and productivity outcomes. This study demonstrated that a reduction in work hour sitting time was not detrimental to work related outcomes. Decreased sitting was observed to potentially improve presenteeism and absenteeism. Prolonged sedentary time was equivalently associated with activity impairment; however, increased sitting was found to enhance cognitive performance. Additionally, physical activity was shown to modestly improve productivity, presenteeism and absenteeism. This study also validated that sleep patterns were associated with work impairment and increased absenteeism.

Aligning with previous workplace sedentary behavior interventions (53, 6), the present study reduced sitting time for the intervention group by 31.52 minutes, decreasing the percent of sitting time from 70.28% to 63.71%. Although the magnitude of effect did not achieve significance given the small sample, the observed change in sitting time occurred without a decrease in work-related measures and a pattern of change to indicate potential improvements in these measures. Furthermore, a decreased pattern of sitting time suggested an improvement in productivity and presenteeism, despite the non-significant findings. The most recent study investigating sedentary behavior and employee presenteeism found that sedentary employees were twice as likely to report higher levels of presenteeism (21). This association was discovered exclusively during non-work hours and also lacked subject variability, as the majority of participants initially reported no work impairment or low presenteeism (21).

The association between sedentary behavior and employee presenteeism is a relatively new concept, hence has produced mixed findings. While some studies have suggested that breaking up sedentary time can benefit work performance (118) others found that increasing postural variation did not adversely affect work performance (62, 53). A multi-component intervention comparable to the present study, demonstrated that work-related outcomes (work performance, absenteeism and presenteeism) was not affected by a decrease in workday sitting time (53). This study was not statistically powered to assess work-related outcomes and used an instrument designed to assess the impact of office noise to measure work performance. A cluster randomized control trial “Stand Up Victoria” (currently in progress) could perhaps provide more insight into the association between sedentary behavior and presenteeism. This intervention would be the first cluster randomized trial and the longest to date (1 year).

Another outcome from the present study suggested that physical activity was linked to improved productivity, presenteeism and absenteeism. Moreover, a decrease in absenteeism and presenteeism was associated with increased physical activity (both light intensity and more intense forms of physical activity). This finding coincides with prior studies which demonstrated that those who engaged in light intensity physical activity, during work and non-work hours, were more likely to improve their presenteeism (21, 78). Additionally, researchers have identified physical activity as positively associated with psychosocial health in the workplace (21).

Our findings confirmed that health impairments and absenteeism are linked to prolonged sedentary periods. A significant association was found between activity impairment and increased sedentary time. Although this result was not specific to a health impairment, there is sufficient evidence which implicates the risks of sedentary time. Emerging bodies of literature indicates that sedentary behavior as a distinct risk factor for multiple health outcomes (67, 43, 60, 61, 105). Sedentary work can subsequently increase the risk of chronic diseases (67), thus sedentary employees with a chronic health condition are more likely to be absent from work (122).

Our study presented conflicting results across the cognitive performance measure that were assessed. This is consistent with current literature. Overall, our study demonstrated that cognitive functioning improvements were modestly associated with increased sitting time. Sedentary behavior has been positively associated with cognition for the older adult population because they were engaged in cognitively stimulating sedentary tasks (i.e. computer use) (131). Similarly, with an adult distance learner population, sedentary behavior was also found to positively enhance learning outcomes, as physical activity was found to detract from academic time (42). Additionally, past research has shown that postural allocation has varying effects on domains of cognitive performance (7) and is task specific (65, 5). Our results also demonstrated that cognitive performance improved with increased physical activity (light and MVPA). Physical activity has been established as an integral element in promoting effective cognitive functioning (68) and can affect “neuroelectric processes underlying executive control through the increased allocation of neuroelectric resources and through changes in cognitive processing and stimulus classification speed” (58).

Lastly, our findings supported the existing evidence that sleep parameters are linked to work productivity measures, and insufficient sleep can consequently affect work impairment and increased absenteeism. Significant associations were observed between improvements in productivity and presenteeism, and more healthful sleep patterns (less wakefulness after sleep onset, greater sleep efficiency). Furthermore, a decrease in sleep onset latency and total sleep time was shown to negatively affect health impairment. Past investigations suggested that those who were at-risk for a sleep disorder had negative work outcomes, and presenteeism was a significant issue (120). Therefore, the risk for sleep disorders increased the likelihood of negative work outcomes, including occupational accidents, absenteeism and presenteeism (88,120, 96). When administering the same productivity scale, Health and Work Performance Questionnaire (HPQ), investigators found that the estimated cost of lost productivity time was greater in poor sleepers. Moreover, workers with shorter sleep duration had a higher annual cost due to presenteeism (96). Consistent research suggests that sleep is vital to well-being in the workplace. Inadequate sleep can affect productivity, workplace injuries, absenteeism, and medical care expenditures (96). Overall, our study confirms that sleep is a vital component to cognitive performance and productivity in the workplace.

To our knowledge, the productivity instruments utilized in the present study has not detected or quantified the appropriate responsiveness to change for a healthy, sedentary employee population. Nonetheless, some instruments have been evaluated to determine the responsiveness for productivity and certain disease/condition specific measures. The EWPS instrument has been shown to demonstrate sensitivity in change scores for a depressed population, a disease specific version of the WPAI instrument also established change for patients with ankylosing spondylitis, and the SPS-6 detected a 20% effect size in the presenteeism score for migraine headaches (127). Additionally, an arbitrary assumption stated that a 20% change with the HPQ scale would lead to a positive or negative change in work performance (69). A prior study has shown that questionnaires with a greater range of response option to each item, are more sensitive in detecting changes in presenteeism following an intervention (21).

The assessment for productivity and presenteeism is complex as instrument responsiveness and generalizability vary widely. First of all, there is a lack of consistency in the units of productivity and presenteeism measurement. For some scales, such as WPAI:GH and HPQ, a meaningful change of lost productivity translates into a monetary estimate. However this monetary amount would vary based on the employer size and this amount does not directly derive productivity loss or evaluate indirect costs of the workplace. Furthermore the instruments used for the present study assessed recall periods that were not extensive, ranging from the prior week to the past month.

Strengths/Limitations

A strength of our study was the ability to objectively measure postural and movement patterns with activPAL and GeneActiv wearable sensors. The activPAL is a highly validated measure of posture and motion (109), and the GeneActiv is a reliable device capable of classifying the intensity of physical activity in adults (37). We observed very little non-wear time during work hours for both activPAL and GeneActiv, strengthening our confidence in the accuracy and representativeness of our results. Along with the wearable sensors, we administered multiple validated questionnaires to assess productivity and presenteeism measures. Another strength was the use of the computerized cognitive battery, Cogstate, to detect cognitive performance in the workplace over an extended period. The 16 week intervention allowed us to examine the long term efficacy of decreasing sitting time and its impact on productivity, presenteeism and cognitive performance. Nevertheless, there were several limitations to our study. The Work Limitations Questionnaire, which has been recently shown to have good psychometric characteristics particularly when assessing sedentary behavior and physical activity (20), would have enhanced the assessment of work performance. Our small sample size limited our ability to detect small to medium effects in our outcome variables. Lastly, due to naturalistic approach of the study, we were unable to randomize groups for statistical control and homogeneity; however, the inclusion of a comparison group strengthened our design.

Conclusion

This study examined the impact of a sedentary behavior intervention on work-related outcomes. Reducing sitting time did not negatively impact work-related outcomes. Our study adds to the increasing evidence that prolonged sedentary time is associated with decreased productivity, increased absenteeism and presenteeism in the workplace. A break in sitting time can potentially break up the monotony of the workday and improve productivity. Our study also illustrated that objectively assessing work performance is difficult to capture, and can produce conflicting results. However, sleep patterns was established to have a substantial association with work impairment and absenteeism. Although health risks associated with sedentary behavior are becoming more evident, the association between occupational sedentary behavior and its impact on work related and health outcomes warrants further investigation. Further research should utilize a randomized controlled sample, measure primary outcomes more frequently, and send a targeted message that postural variation does not impair productivity or cognition.

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APPENDIX A

RECRUITMENT FLYER

Participate in a study to reduce sitting time and increase physical activity in the workplace

Stand and Move ASU

Who can participate?

- Staff and faculty in Health Solutions in the newly constructed NHI-2 5th floor
- You must be 18 years or older and able to safely exercise

What does a participant need to do?

- Be willing to participate in laboratory visit & wear a monitoring device for physical activity for 7 consecutive days at **baseline** and **post test**

Study Details

- 4 month study
- Requires 2 visits to the ASU laboratory on the downtown campus (ABC 1 building)
- Receive newsletters on reducing sitting time and increasing physical activity at work
- Use of 3 "shared" treadmill walking workstations
- Free copy of physical activity levels and blood results

Individuals interested in participating in this study should contact Anna Park by phone at 213-327-8716 or by email at Anna.Park@asu.edu

Do you want to create a healthy work environment?

You are invited to participate in an office ergonomics study

ENERGIZE YOUR DAY

Who can participate?

- Staff and faculty in Health Solutions Academic Services

  AND
- 18 years and older

Study Details

- 4 month study
- Requires 2 visits to the ASU laboratory on the downtown campus (ABC 1 building)
- Receive newsletters on improving office ergonomics, posture and overall well being at work
- Free copy of physical activity levels and blood results

What does a participant need to do?

- Be willing to participate in two laboratory visits and wear a monitoring device for physical activity for 7 consecutive days twice, at **baseline** and **post test**

Individuals interested in participating in this study should contact Anna Park by phone at 213-327-8716 or by email at Anna.Park@asu.edu

APPENDIX B

INFORMED CONSENT

STAND AND MOVE ASU
CONSENT FORM

INTRODUCTION

The purposes of this form are to provide you (as a prospective research study participant) information that may affect your decision as to whether or not to participate in this research and to record the consent of those who agree to be involved in the study.

RESEARCHERS

Matthew Buman, PhD (P-I), Noe Crespo, PhD (Co-I), Anna Park (Co-I) of the School of Nutrition and Health Promotion have invited your participation in a research study.

STUDY PURPOSE

The purpose of the research is to test two different intervention approaches to reduce time spent sitting, being physically activity, improving cardiometabolic health risks, and work productivity within the workplace. One approach focuses on changes to the workplace environment that encourage standing and moving, and the other focuses on enhancing office ergonomics and efficiency practices. Both approaches will receive weekly email communication with topics related to the intervention approach.

DESCRIPTION OF RESEARCH STUDY

If you decide to participate, then as a study participant you will join a study involving research of sitting, physical activity, health, and productivity within the workplace. The study will be 4 months in duration. There will be no randomization. If you are an ASU faculty or staff member that will be re-located to the 5th floor of Nursing and Health Innovation 2 (NHI2), you will be given the intervention approach that encourages standing and moving. If you are ASU faculty or staff member in the Academic Services Unit in the Mercado Building, you will be given the intervention approach to enhance office ergonomics and efficiency.

At the commencement and conclusion of the study, you will be asked to participate in a laboratory visit for a blood draw at the Arizona Biomedical Collaborative (ABC1) building on the ASU Downtown Phoenix campus (425 N. 5th Street, Phoenix, AZ 85004). This will take approximately 2 hours and will require a fast for 12 hours prior to your study visits. This means that you should not eat or drink anything but water starting 12 hours before your appointment. This appointment will be scheduled early in the morning so that you can come before you have breakfast. We will give you a light snack after each blood draw.

will take place during the morning time after an overnight fastWe will collect a blood sample to measure your blood lipids (cholesterol and other fats), sugar, and other indicators of risk for heart disease and diabetes, and of how cholesterol and sugar are processed in your body. The total amount of blood that we will draw will be 15 ml (about 1 tablespoon). No genetic analysis will be performed on any blood collected.

Additionally, during this visit, you will be asked to complete surveys, obtain your height and weight, take your blood pressure, and have your blood drawn. You will be asked to wear an accelerometer (GeneActiv) and activity monitor (activPAL) for one week. These devices will be used to monitor how much time you spend sitting and moving throughout the day and how you sleep at night. If desired, you can elect to skip questions and decline participation in any aspect of the study.

If you say YES, then your participation will last for 4 months. Demographic, contact information, physical activity levels, blood pressure, and a laboratory visit will be required prior to beginning the 4 month period and at the conclusion. Approximately 100 subjects will be participating in this study locally.

RISKS

There is a minimal risk of injury while standing on the sit-stand workstation or walking on the treadmill workstation; you can fall or strain a muscle. Another potential risk is that you may find your work productivity declining slight when you are standing or walking. However, if this should happen, you will have the option of sitting down.

If you decide to participate in this study, then you may face a risk of bruising and discomfort, dizziness and fainting associated with blood drawing. However, this risk is small. There is also a small risk that you will feel uncomfortable from hunger, dizzy, or lightheaded due to fasting. The research team will minimize these risks by using trained personnel to draw your blood and by giving you a snack after the blood draw.

You might experience mild discomfort during blood pressure testing as the cuff inflates. However, the risk is small, and discomfort will go away after the cuff is deflated.

BENEFITS

Although there may be no direct benefits to you, the possible benefit of your participation in the research is the possibility to change sedentary nature of the workplace and increase overall health and well-being of office workers. All participants will receive information about their physical activity levels and laboratory results.

NEW INFORMATION

If the researchers find new information during the study that would reasonably change your decision about participating, then they will provide this information to you.

CONFIDENTIALITY

All information obtained in this study is strictly confidential unless disclosure is required by law. The results of this research study may be used in reports, presentations, and publications, but the researchers will not identify you. In order to maintain confidentiality of your records, Dr. Matthew Buman will assign a unique number to each participant; no names or contact information will be recorded on the data sheet.

All signed consent forms, contact information, name-number pairings will be kept in a separate file form the number coded data sheets. All forms and data sheets will be kept in a locked file cabinet in the PI's office, and only the investigators will have access to this office. Your data will be retained for five years following the completion of this study after which it will be shredded.

WITHDRAWAL PRIVILEGE

Participation in this study is completely voluntary. It is ok for you to say no. Even if you say yes now, you are free to say no later, and withdraw from the study at any time. Your decision will not affect your relationship with Arizona State University or otherwise cause a loss of benefits to which you might otherwise be entitled.

COSTS AND PAYMENTS
There is no payment for your participation in the study.

COMPENSATION FOR ILLNESS AND INJURY
If you agree to participate in the study, then your consent does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury.

VOLUNTARY CONSENT
Any questions you have concerning the research study or your participation in the study, before or after your consent, will be answered by Dr. Matthew Buman, School of Nutrition and Health Promotion, Arizona State University, contactable at 602-827-2289.

If you have questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk; you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at 480-965 6788.

This form explains the nature, demands, benefits and any risk of the project. By signing this form you agree knowingly to assume any risks involved. Remember, your participation is voluntary. You may choose not to participate or to withdraw your consent and discontinue participation at any time without penalty or loss of benefit. In signing this consent form, you are not waiving any legal claims, rights, or remedies. A copy of this consent form will be given (offered) to you.

Your signature below indicates that you consent to participate in the above study.

______________________________	____________________________	____________
Subject's Signature	Printed Name	Date
______________________________	____________________________	____________
Legal Authorized Representative (if applicable)	Printed Name	Date

INVESTIGATOR'S STATEMENT
"I certify that I have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature. These elements of Informed Consent conform to the Assurance given by Arizona State University to the Office for Human Research Protections to protect the rights of human subjects. I have provided (offered) the subject/participant a copy of this signed consent document."

Signature of Investigator________________________________ Date____________

APPENDIX C

INTERVENTION NEWSLETTER

STAND and MOVE

ASU College of Health Solutions
ARIZONA STATE UNIVERSITY

ASU College of Nursing & Health Innovation
ARIZONA STATE UNIVERSITY

Defining Sedentary Behavior

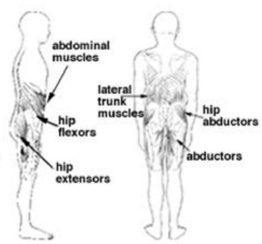
UNDERSTANDING THE HEALTH RISKS OF SEDENTARY BEHAVIOR

Sedentary behavior refers to any waking activity with very low energy expenditure (≤1.5 METS).[1] Research has shown a significant correlation between sedentary behavior and obesity, and the development of chronic diseases such as type 2 diabetes, cancers and cardiovascular disease. [2] People who stand and move around are more likely to have healthier blood lipids and glucose than those who are sedentary. The breaks in sitting time can improve metabolic health. [3]

Sedentary activities include:
- Sitting
- Lying down
- Watching TV
- Computer use
- Driving

PHYSIOLOGY?

Postural muscles in the legs, back and neck play an integral part in maintaining posture during standing or light exercise. These muscles are crucial in processing fat and cholesterol. [4] Despite getting regular exercise, people who sit for long periods of time and do not exercise these postural muscles, may experience health problems.



TOO MUCH SITTING IS DISTINCT FROM TOO LITTLE EXERCISE

Exercise is independent of sedentary time.[2] The benefits of physical activity are offset by the amount of time spent sitting.[4] Even among the most physically active individuals, high amounts of sedentary time cannot be counterbalanced.

TIP: Start the day off by performing simple tasks, i.e. reading emails or prioritizing your day, while standing.

TEST YOUR KNOWLEDGE! CLICK HERE!

https://docs.google.com/forms/d/1Q5OaXJYKtO3mhzoobI2hZqzK8cHX1QWVbvZsG9iMPgw/viewform

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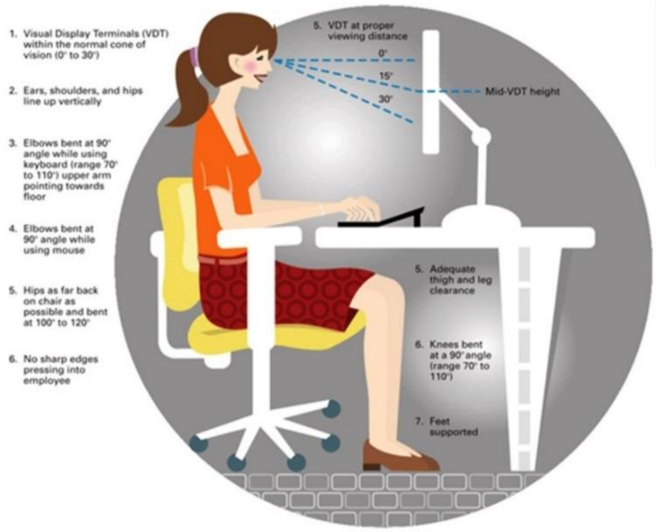
APPENDIX D

COMPARISON NEWSLETTER

ASU School of Nutrition & Health Promotion
ARIZONA STATE UNIVERSITY

ASU College of Nursing & Health Innovation
ARIZONA STATE UNIVERSITY

Energize Your Work Day



Creating a Healthy Workstation

What is Ergonomics?

Ergonomics is the study of how your body interacts with your environment when you perform a task or activity. Ergonomics often involves arranging your environment-including equipment, tools, lighting, and how you do a task-to fit you and the activity you are doing. ***Office ergonomics focuses on arranging your work environment to fit your needs while you do your job.***

When your workstation is set up properly, you may be less likely to have problems such as headaches or eyestrain, possibly reduce neck and back pain, and perhaps prevent conditions such as carpal tunnel syndrome that can be related to repetitive activities.

OFFICE

The work area should be large enough to accommodate you, allow the full range of motions involved in performing required tasks, and provide room for the equipment and materials that make up the workstation. Appropriately placing lighting and selecting the right level of illumination can enhance your ability to see monitor images. Ventilation and humidity levels in office work environments may affect user comfort and productivity.

Quick Tips

- Arrange your office to minimize glare from overhead lights, desk lamps, and windows.
- Maintain appropriate air circulation.
- Avoid sitting directly under air conditioning vents that "dump" air right on top of you.
- Stretch your fingers, hands, arms, and torso.
- Stand up and walk around for a few minutes periodically.

See the attachment to set up a healthy workstation TODAY!

Check your knowledge! CLICK HERE

Resources:
www.OSHA.gov
www.WebMD.com
www.CDC.gov

APPENDIX E

ACTIVITY LOG

Subject ID #

DAILY ACTIVITY LOG AND SLEEP DIARY

PLEASE RECORD ANY TIMES DURING WHICH YOU WERE NOT WEARING YOUR ACCELEROMETER FOR AT LEAST 20 MINUTES. PLEASE ENTER THE **EXACT** TIME AND ONE OF THE FOLLOWING CODES:

GA: GENEactiv **AP: activPAL**
1 - BATHING/SHOWERING 2 – SWIMMING/WATER ACTIVITIES 3 – FORGOT
4 – OTHER ***(indicate reason)***

Time	**DATE:**
12:00 am	
01:00 am	
02:00 am	
03:00 am	
04:00 am	
05:00 am	
06:00 am	
07:00 am	
08:00 am	
09:00 am	
10:00 am	
11:00 am	
12:00 pm	
01:00 pm	
02:00 pm	
03:00 pm	
04:00 pm	
05:00 pm	
06:00 pm	
07:00 pm	
08:00 pm	
09:00 pm	
10:00 pm	
11:00 pm	

Wake Time: ____________________

Work Arrival Time: ____________________

Work Departure Time: ____________________

Bed Time: ____________________

SLEEP DIARY

1. Did you take a nap? ☐ Yes ☐ No
   a) For how long? ______ mins.
   b) At what time? __________
2. How many total hours did you sleep?
   ______ hours

3.Counting from the time you wished to fall asleep, how many minutes did it take you to fall asleep last night?
   ______ mins.

5. How many times did you wake up or get up during the night?
   ______ times
6. What is the total number of minutes you were awake during the middle of the night once you fell asleep (middle of the night)?
   ______ mins.
7. Rate the quality of your sleep:
   [1 = very poor; 2 = poor; 3 = fair; 4 = good; 5 = excellent]
   ______
8. Do you feel that you got an adequate amount of sleep?
   ☐ Yes ☐ No

APPENDIX F

DEMOGRAPHICS

What is your gender?

- ❍ Male (1)
- ❍ Female (2)

What is your current age? (U.S. Census)

- ❍ 18 to 20 (1)
- ❍ 20 to 24 (2)
- ❍ 25 to 34 (3)
- ❍ 35 to 44 (4)
- ❍ 45 to 54 (5)
- ❍ 55 to 64 (6)
- ❍ 65 or over (7)

What is your race?

- ❍ White/Caucasian (1)
- ❍ African American (2)
- ❍ Hispanic (3)
- ❍ Asian (4)
- ❍ Native American (5)
- ❍ Pacific Islander (6)
- ❍ Other (7)

Please indicate your marital status:

- ❍ Single (1)
- ❍ Married (2)
- ❍ Separated (3)
- ❍ Divorced (4)
- ❍ Widowed (5)
- ❍ Never Married (6)

What is your current status?

- ❍ Single, never married (1)
- ❍ Married without children (2)
- ❍ Married with children (3)
- ❍ Divorced (4)
- ❍ Seperated (5)
- ❍ Widowed (6)
- ❍ Living w/ partner (7)

What is the highest level of education you have completed?
- Less than High School (1)
- High School / GED (2)
- Some College (3)
- 2-year College Degree (4)
- 4-year College Degree (5)
- Masters Degree (6)
- Doctoral Degree (7)
- Professional Degree (JD, MD) (8)

What type of job do you perform?
- Sales (1)
- Customer service (2)
- Technical (3)
- Clerical (4)
- Managerial (5)
- Training (6)
- Professional (7)
- Other (8) ____________________

How would you describe your job?
- Full-time faculty (1)
- Full-time staff (2)
- Part-time faculty (3)
- Part-time staff (4)

Do you currently smoke? If yes, please answer the table below
- Yes (1)
- No (2)

Answer If Do you currently smoke? If yes, please answer the table b... Yes Is Selected

In the table below please check in the boxes labeled Yes, No, Times per day, if you use or do not use that form of nicotine. Please write in the box below how many times per day you use each form of nicotine.

	Yes (1)	No (2)
Cigars (1)	❍	❍
Pipes (2)	❍	❍
Cigarettes (3)	❍	❍
Smokeless/Electronic cigarettes (4)	❍	❍
Chew (5)	❍	❍

APPENDIX G

ENDICOTT WORK PRODUCTIVITY SCALE (EWPS)

Study ID#

Do you receive pay or any other money for any type of work?
- ❍ Yes (1)
- ❍ No (2)

Do you do volunteer work?
- ❍ Yes (1)
- ❍ No (2)

If you do not receive money for your work and do not do volunteer work, please indicate why you do not:
- ❍ I am physically ill (1)
- ❍ I am too upset, depressed, or nervous (2)
- ❍ I can't find work (3)
- ❍ Other (please describe) (4)

I am self-employed
- ❍ Yes (1)
- ❍ No (2)

I work for someone else
- ❍ Yes (1)
- ❍ No (2)

I have a boss/supervisor
- ❍ Yes (1)
- ❍ No (2)

I have co-workers with whom I must work
- ❍ Yes (1)
- ❍ No (2)

I supervise others at work
- ❍ Yes (1)
- ❍ No (2)

I deal with clients/customers/vendors

- ❍ Yes (1)
- ❍ No (2)

How many hours do you work or would you be usually expected to work ?

How many hours did you work last week?

If you missed time off at work last week, please note all the reasons why:

- ❍ I had a day off (Holiday/vacation) (1)
- ❍ I was physically ill (2)
- ❍ Too upset, depressed, nervous (3)
- ❍ Other (4)

During the past week, how frequently did you...

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Almost Always (5)
Arrive at work late or leave work early? (1)	❍	❍	❍	❍	❍
Take longer lunch hours or coffee breaks? (2)	❍	❍	❍	❍	❍
Just do no work at times when you would be expected to be working? (3)	❍	❍	❍	❍	❍
Find yourself daydreaming, worrying, or staring into space when when you should be working? (4)	❍	❍	❍	❍	❍
Have to do a job over because you made a mistake or your supervisor told you to do a job over? (5)	❍	❍	❍	❍	❍
Waste time looking for misplaced supplies, materials, papers, phone numbers, etc? (6)	❍	❍	❍	❍	❍
Find you have forgotten to call someone? (7)	❍	❍	❍	❍	❍
Find you have forgotten to respond to a request? (8)	❍	❍	❍	❍	❍
Become annoyed with or irritated by co-workers, boss/supervisor, clients/customers/vendors or others? (9)	❍	❍	❍	❍	❍
Become impatient with others at work? (10)	❍	❍	❍	❍	❍
Avoid attending meetings? (11)	❍	❍	❍	❍	❍
Avoid interaction with	❍	❍	❍	❍	❍

co-workers, clients, vendors, or supervisors? (12)					
Have a co-worker redo something you had completed? (13)	❍	❍	❍	❍	❍
find it difficult to concentrate on the task at hand? (14)	❍	❍	❍	❍	❍
Fall asleep unexpectedly or become very sleepy while at work? (15)	❍	❍	❍	❍	❍
Become restless while at work? (16)	❍	❍	❍	❍	❍
Notice that your productivity for the time spent is lower than expected? (17)	❍	❍	❍	❍	❍
Notice that your efficiency for the time spent is lower than expected? (18)	❍	❍	❍	❍	❍
Lose interest or become bored with your work? (19)	❍	❍	❍	❍	❍
Work more slowly or take longer to complete tasks than expected? (20)	❍	❍	❍	❍	❍
Have your boss/coworkers remind you to do things? (21)	❍	❍	❍	❍	❍
Not want to return phone calls or put off returning phone calls? (22)	❍	❍	❍	❍	❍
Have trouble organizing work or setting priorities? (23)	❍	❍	❍	❍	❍
Fail to finish assigned tasks? (24)	❍	❍	❍	❍	❍
Feel too exhausted to do your work? (25)	❍	❍	❍	❍	❍

APPENDIX H

WORK PRODUCTIVITY AND ACTIVITY IMPAIRMENT QUESTIONNAIRE:

GENERAL HEALTH V2.0 (WPAI:GH)

The following questions ask about the effect of your health problems on your ability to work and perform regular activities. By health problems we mean any physical or emotional problem or symptom. *Please fill in the blanks or circle a number, as indicated.*

1. Are you currently employed (working for pay)? ____ NO ____ YES

If NO, check "NO" and skip to question 6.

The next questions are about the **past seven days**, not including today.

2. During the past seven days, how many hours did you miss from work because of your health problems? *Include hours you missed on sick days, times you went in late, left early, etc., because of your health problems. Do not include time you missed to participate in this study.*

    _____HOURS

3. During the past seven days, how many hours did you miss from work because of any other reason, such as vacation, holidays, time off to participate in this study?

    _____HOURS

4. During the past seven days, how many hours did you actually work?

    _____HOURS *(If "0", skip to question 6.)*

5. During the past seven days, how much did your health problems affect your productivity while you were working?

Think about days you were limited in the amount or kind of work you could do, days you accomplished less than you would like, or days you could not do your work as carefully as usual. If health problems affected your work only a little, choose a low number. Choose a high number if health problems affected your work a great deal.

Consider only how much health problems affected productivity while you were working.

Health problems had no effect on my work	0	1	2	3	4	5	6	7	8	9	10	Health problems completely prevented me from working

CIRCLE A NUMBER

6. During the past seven days, how much did your health problems affect your ability to do your regular daily activities, other than work at a job?

By regular activities, we mean the usual activities you do, such as work around the house, shopping, childcare, exercising, studying, etc. Think about times you were limited in the amount or kind of activities you could do and times you accomplished less than you would like. If health problems affected your activities only a little, choose a low number. Choose a high number if health problems affected your activities a great deal.

Consider only how much health problems affected your ability to do your regular daily activities, other than work at a job.

Health problems had no effect on my daily activities	0	1	2	3	4	5	6	7	8	9	10	Health problems completely prevented me from doing my daily activities

CIRCLE A NUMBER

APPENDIX I

WORLD HEALTH ORGANIZATION HEALTH AND WORK PERFORMANCE

QUESTIONNAIRE (HPQ)

B3. About how many hours altogether did you work in the past 7 days?   (If more than 97, enter 97.)

B4. How many hours does your employer expect you to work in a typical 7-day week? (If it varies, estimate the average. If more than 97, enter 97.)

B5. Now please think of your work experiences over the past 4 weeks (28 days). In the spaces provided   below, write the number of days you spent in each of the following work situations.   In the past 4 weeks (28 days), how many days did you...

	Number of days (00-28) (1)
B5a). ...miss an ENTIREwork day because of problems with your physical or mental health? (Please include only days missed for YOUR own health, not someone else's health.) (1)	
B5b). ...miss an entire work day for any other reason (including vacation)? (2)	
B5c). ...miss PART of a work day because of problems with your physical or mental health? (Please include only days missed for YOUR own health, not someone else's health.) (3)	
B5d). ...miss part of a work day for any other reason (including vacation)? (4)	
B5e). ...come in early, go home late, or work on your day off? (5)	

B6. About how many hours altogether did you work in the past 4 weeks (28 days)? (See examples   below.)   Examples for Calculating Hours Worked in the Past 4 Weeks   40 hours per week for 4 weeks = 160 hours 35 hours per week for 4 weeks = 140 hours   40 hours per week for 4 weeks with 2 8-hour days missed = 144 hours   40 hours per week for 4 weeks with 3 4-hour partial days missed = 148 hours   35 hours per week for 4 weeks with 2 8-hour days missed and 3 4-hour partial days missed = 112 hours

On a scale from 0 to 10 where 0 is the worst job performance anyone could have at your job and 10 is the performance of a top worker,

______ B9.how would you rate the usual performance of most workers in a job similar to yours? (1)

______ Using the same 0-to-10 scale, how would you rate your usual job performance over the past year or two? (2)

______ B11. Using the same 0-to-10 scale, how would you rate your overall job performance on the days you worked during the past 4 weeks (28 days)? (3)

APPENDIX J

STANFORD PRESENTEEISM SCALE 6 (SPS-6).

Please use the following scale: * Note that the words ‘back pain,’ ‘cardiovascular problem,’ ‘illness,’ ‘stomach problem,’ or other similar descriptors can be substituted for the words ‘health problem’ in any of these items.+

	Strongly Disagree (1)	Somewhat Disagree (2)	Uncertain (3)	Somewhat Agree (4)	Strongly Agree (5)
Because of my (health problem)*, the stresses of my job were much harder to handle. (1)	❍	❍	❍	❍	❍
Despite having my (health problem)*, I was able to finish hard tasks in my work. (2)	❍	❍	❍	❍	❍
My (health problem)* distracted me from taking pleasure in my work. (3)	❍	❍	❍	❍	❍
I felt hopeless about finishing certain work tasks, due to my (health problem)*. (4)	❍	❍	❍	❍	❍
At work, I was able to focus on achieving my goals despite my (health problem)*. (5)	❍	❍	❍	❍	❍
Despite having my (health problem)*, I felt energetic enough to complete all my work. (6)	❍	❍	❍	❍	❍